THE JOURNAL OF WILDLIFE MANAGEMENT

VOLUME 15 APRIL, 1951 NUMBER 2

MULE DEER IN NEBRASKA NATIONAL FOREST

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Deer have returned in notable and even surprising numbers to much of Nebraska during the last twenty years. Coincidentally with this general and natural stocking or restocking of most, if not all of the state's available deer habitat, the population of mule deer, *Odocoileus hemionus hemionus* (Rafinesque), on the Bessey Division of Nebraska National Forest (1)* increased until in the late 1930's it became apparent that herd reduction measures would sooner or later be needed to keep the animal's numbers within the biological limits of its range, and to protect the forest plantations. Investigations relative to management of deer in that area were initiated in 1944. A controlled hunt was conducted on the Forest in December 1945. Studies, albeit of limited scope, are being continued. This paper is offered in an attempt to report all information that is available relative to the management of mule deer in that area.

ACKNOWLEDGEMENTS

The efforts of many persons have made possible this report. We are especially grateful to those members of the United States Forest Service whose enthusiastic, friendly, and able cooperation has contributed immeasurably to the data reported here, and added greatly to the pleasure and value of the field work—namely: M. F. Brandborg, V. J. Dayharsh, Dwight A. Hester, Ralph R. Hill, Albert B. Hovey, John Maslak, Thomas C. Pender, Herbert Schwan, George W. Siewart, Carl Smith and Russell Smith.

To D. I. Rasmussen of the U. S. Forest Service, and to William T. McKean and Roy N. Bach of the North Dakota Game and Fish Department we are indebted for technical contributions to an understanding of deer management problems in Nebraska National Forest.

To all personnel of the Nebraska Game, Forestation and Parks Commission who have in any way helped in getting the information presented here—particularly the Conservation Officers whose efforts during the December 1945 deer hunt were especially contributory—we express appreciation.

It is a pleasure to extend our thanks to Mrs. Myron H. Swenk for permission to incorporate unpublished material from the notes of the late Professor Swenk; to James Olson and Marvin Kivett of the Nebraska State Historical Society for historical and

*Parenthetical numbers in bold face refer to numbered localities on map, Fig. 1.

archeological information; to H. W. Manter, Department of Zoology, University of Nebraska, for identification of helminth parasites; to H. Douglas Tate, Agricultural Chemicals Development, Naugatuck, Connecticut, who identified the parasitic insects; and to Eli M. Oboler, Librarian, Idaho State College, for invaluable help relative to references.

Much of this paper is based upon studies undertaken with Federal Aid in Wildlife Restoration Funds under Nebraska Pittman-Robertson Projects 4-R, 13-R, and 15-R.

HISTORICAL REVIEW

The Rocky Mountain mule deer is native to Nebraska. A fragment of antler apparently of this species was unearthed near the southeastern corner of the state in Richardson County (2) by a field party of the Nebraska State Historical Society in June 1935. The fragment was found among other various materials in a buried cache or trash-filled storage pit evidencing occupancy of the site by man and contemporary existence of the mule deer in what is considered to be late prehistoric times, probably not earlier than 1600 A.D. This record has been previously reported under the common name black-tailed deer (Hill and Wedel, 1936:64).

Rafinesque (1817) based his diagnosis of the species on a description written

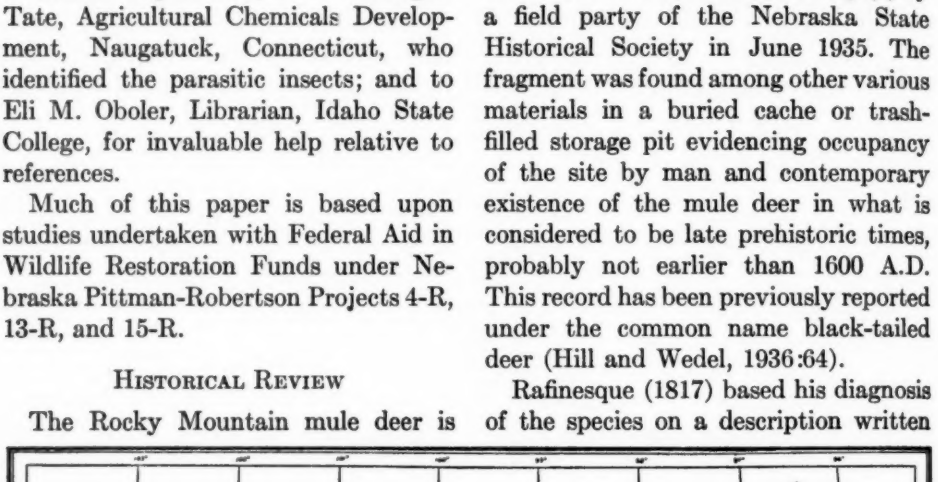

FIG. 1.—Map showing localities referred to in the historical review of the Rocky Mountain mule deer in Nebraska. The sandhill areas are generalized. 1. Nebraska National Forest, Bessey Division. 2. Southeastern Richardson County; the Leary Indian village and burial site at which antler of mule deer excavated by Nebraska State Historical Society. 3. Big Sioux River; type locality of *Odocoileus hemionus hemionus* (Rafinesque). 4. Mouth of Ponca Creek, northwestern Knox County; mule deer observed by member of Lewis and Clark expedition, 1804. 5. Bonhomme Island near which mule deer observed by Lewis and Clark expedition, 1804. 6. Antelope County; mule deer present 1868–1883. 7. Northern Boone County; a mule deer shot July 4, 1879. 8. Cedar River. 9. North Loup River (mule deer numerous in rough country bordering these two rivers as late as winter of 1880). 10. Logan Creek, near Dakota City; mule deer killed in spring of 1871. 11. South branch of Timber Creek, near Fullerton; a mule deer shot here in 1880, mounted head in Nebraska State Historical Society Museum, Lincoln. 12. Long Pine, Brown County. 13. Valentine, Cherry County. 14. Hay Springs, Sheridan County. (Mounted specimens reported to have been taken in these localities—12, 13, 14—in the early 1880's.) 15. Dismal River; mule deer occurred here in late 1880's. Apparently principal center of survival of this species in Nebraska at the turn of the century. 16. Pine Ridge. 17. Hat Creek Basin. 18. Niobrara River (Areas—16, 17, 18—in which the mule deer apparently persisted in small numbers until the return of increasing populations in the last twenty years).

by Charles LeRaye (Cutler 1812) of some of these deer that he saw in the vicinity of the Big Sioux River (3) in South Dakota in 1802. They were again noted in the same general region by the Lewis and Clark expedition in 1804. One of the hunters of the expedition, a Private Shields, reported that he saw "several black tailed Deer" in the vicinity of a deserted Indian village near the mouth of Ponca Creek (4) in what is now northwestern Knox County, on September 5, 1804 (Clark's Journal: Thwaites, 1904, p. 140). These were the first Rocky Mountain mule deer observed by the expedition. Captain Clark also commented on the species: "Mule or Black tail Deer . . . are found as low as the ancient fortification and on Bon homm Island or good mans Island. . ." (5), these two locations being in juxtaposition in northeastern Knox County, about 25 miles down the Missouri River from Shield's observation cited above.

In his historical account of Antelope County (6), Nebraska, covering the period 1868 to 1883, Leach (1909) states: "The blacktail or mule deer were found here, but they were not at all abundant. . . . Two at least were killed in the rough part of Logan township, one in Lincoln township, and a few were seen in the rough lands of the Verdigris, in the northwestern part of the county." On July 4, 1879 a deer which "proved to be a blacktail" was shot in extreme northern Boone County (7). "They were very numerous in the rough country bordering the Loup and Cedar (8) rivers as late as the winter of 1880." Leach was probably referring to the North Loup River (9).

In 1905 Mr. L. Sessions of Norfolk, Nebraska, reported (M. H. Swenk, unpublished notes) that "the last known killing of a mule deer in northeastern Nebraska was one shot on Logan Creek near Dakota City (10) in the spring of 1871." A mounted head of a mule deer buck on display in the Nebraska State Historical Society Museum, State House, Lincoln, bears the following data: "Shot in 1880 on the South branch of Timbers (now Timber) Creek, near Fullerton (11), Nebraska by George W. Brown. Donor—Harry Brown 5877." Swenk recorded in his unpublished notes that Professor Lawrence Bruner* said in 1914 that he had seen mounted specimens of the Rocky Mountain mule deer "shot near Long Pine (12) in Brown County, in Cherry County near Valentine (13) and in Sheridan County near Hay Springs (14), in the early 1880's. They also occurred along the Dismal River (15) in the Sandhills. In a trip to Sioux County in 1896 they were seen about the rim rock of the canyons there."

Merritt Cary, in company with M. A. Carriker, spent the period from late May to early August 1901 in the Pine Ridge (16) of Sioux and Dawes counties and adjacent Hat Creek Basin (17), in northwestern Nebraska. Reporting his observations in that area, Cary (1902) states: "Mr. Jas. Hickson of the Tidd and Hickson ranch on Indian Creek informed me that he had frequently killed Black Tail in the breaks along the ridge in the past ten years. This deer must be extremely rare in the region at present, or even extinct, for during the two months I spent in the region I

*Chairman, Department of Entomology, University of Nebraska, 1895–1919.

saw but one track large enough for a Black Tail—this in the second canyon east of Warbonnet." In his review of the mammals of Nebraska, Swenk (1907) stated that "*hemionus* has practically disappeared" from the Pine Ridge "where the white-tailed still persists."

According to C. A. Black of Kearney, Nebraska (Swenk, unpublished notes), in 1904 four mule deer "came to the Fred Black ranch on the Dismal River (15) in Thomas County in front of a prairie fire. The deer remained and increased, and at one time the herd numbered about 150 individuals. By 1916 the number had diminished to something over 50 head. Close to Thanksgiving of 1912, a Plains [*sic*] Mule Deer was shot on Fred Black's ranch on the Dismal River, south of Thedford, Thomas County. As the killing was illegal, Game Warden Miller took up the animal. The specimen was mounted by J. E. Wallace, and was later on exhibit in a saloon at Falls City, Nebraska. The animal was a two-year-old buck with small antlers, so in mounting it a skull with a pair of large antlers, which happened to be at hand, was substituted. The original skull of the Nebraska animal was saved. . ." and is now in the collection of the University of Nebraska State Museum.

In this historical review of the Rocky Mountain mule deer in Nebraska consistent reference to occurrence of the species north of the Platte River appears significant; no historical accounts of its presence south of the Platte were found. Aughey (1880) wrote that the "special habitat of the black tailed deer was north Nebraska, and especially the Niobrara (18) region." It is of particular interest here to note that mule deer apparently persisted in the valley of the Dismal River, and were showing notable increases there during the early years of the existence of the Bessey Division of the Nebraska National Forest.

Mule deer are now common in many northern and western counties, particularly in the rough country adjacent to the North Platte and Niobrara rivers, in Nebraska National Forest, and in the Pine Ridge region of Sioux, Dawes and Sheridan counties. Conservation officers of the Nebraska Game, Forestation and Parks Commission estimated the state's mule deer population at 1,750 in 1940. More recent estimates by conservation officers include 2825 in 1944, 2025 in 1945, 4000 in 1946, 4037 in 1947, and 7150 in 1948.

NEBRASKA NATIONAL FOREST

Approximately 20,000 square miles of north-central and southwestern Nebraska, and adjacent parts of South Dakota and Colorado, are occupied by sandhills. Dunesand, by some not considered a soil, is far more extensive than any of the soils of the sandhill region, and occurs in a monotonous succession of irregularly distributed hills and ridges. Grasses dominate the vegetation and characterize the cover.

The Bessey Division of the Nebraska National Forest is an area of 90,388 acres of typical Nebraska sandhills, located in southeastern Thomas County and southwestern Blaine County near the southeastern border of the sandhill region (Fig. 1). Its northern and southern boundaries roughly parallel the Middle Loup and Dismal rivers, respectively.

The native vegetation of the tract appears to conform predominantly to the dunesand type of Frolik and Shepard (1940: 8, 10, 11–14) and others. In their survey of the vegetative composition and grazing capacity of sandhill range land in a grazed area about 40 miles north of the Bessey Division in 1937, these authors found this vegetative type occurring "on the dune sand" and including "all of the sandhill areas having a rolling or choppy topography." Their report states: "The characteristic aspect of the dune-sand type is due largely to *Calamovilfa longifolia*, but it is somewhat modified by *Sporobolus cryptandrus*. Although unobtrusive in appearance, *Bouteloua hirsuta* ranks second to *Calamovilfa* in percentage of ground covered. These three are the most important constituents of the type and together make up nearly 70 per cent of the total grass density." They list the following additional grasses and grasslike plants as occurring in the dune-sand type: *Muhlenbergia pungens*, *Andropogon scoparius*, *Andropogon hallii*, *Eragrostis trichodes*, *Panicum* spp., *Redfieldia flexuosa*, *Stipa comata*, *Bouteloua gracilis*, *Carex* spp. (dune), *Juncus* spp., *Koeleria cristata*, and *Agropyron smithii*. Frolik and Shepard found that "shrubs often occupy a conspicuous place in the general aspect of the dunes, even though contributing only 7.7 per cent of the density", and that forbs "comprised 13.3 per cent of the vegetative density during 1937."

The only native trees in the vicinity of the National Forest, most of the species of which were deciduous, were found largely along the stream valleys. Under an extensive program of tree planting a coniferous forest has been and is being created (Pl. 5).

The Nebraska National Forest was established by proclamation of President Theodore Roosevelt on April 16, 1902. The first forest plantings were made in the spring of 1903 when 70,000 forest-pulled seedlings of jack and ponderosa pine were planted. At present the Bessey Division contains approximately 24,000 acres of growing evergreen trees. Jack pine, ponderosa or western yellow pine, eastern red cedar or Virginia juniper, and Austrian and Scotch pine are the major species in order of their abundance.

Jack pine plantings are the largest and the oldest (Pl. 5B). Practically all of the trees of this species are large, some exceeding 40 feet in height. Ponderosa pine is considered the most successful pine, although it is attacked by two species of tip moths that materially influence the growth of the younger trees. The eastern red cedar is a native of the general region and grows the most successfully of the evergreens. In recent plantings emphasis has been placed on this species (Pl. 5C). Plantations of red cedar (Pl. 5D) are all relatively young and comprise about 5,000 acres. The use of Scotch and Austrian pines has been discontinued. There are about 1,000 acres of Scotch and 200 to 300 acres of Austrian pine on the area.

Thinning of plantations and pruning of lower branches have been carried on under the silvicultural practices of the United States Forest Service. Forage within the Forest reserve has been utilized by the allotment of grazing permits, except where grazing would interfere with planting activities.

The General Character of the Range. In

the densely timbered areas are to be found relatively small pockets and clearings in which are located thickets of shrubby species as well as grasses and forbs. In the open timber areas the amount of shrubs, grasses, and forbs is relatively greater and the thickets are larger and denser than those in the relatively heavier timber (Pl. 6A). In the open grassland shrubs and forbs are common among the dominant grasses. There are pockets containing dense stands of shrubs covering relatively large areas (Pl. 6B). Occasional trees are found associated with the shrubs (Pl. 6C).

A list of the plants found in important numbers in the three types of forest area includes the following trees, shrubs, and forbs.

Austrian pine (*Pinus nigra*)
Jack pine (*P. banksiana*)
Scotch pine (*P. sylvestris*)
Ponderosa pine (*P. ponderosa*)
Eastern red cedar (*Juniperus virginiana*)
Buckbrush (*Symphoricarpos occidentalis*)
Redroot (*Ceanothus* sp.)
Willow (*Salix* sp.)
Wild Rose (*Rosa* sp.)
Poison Ivy (*Rhus toxicodendron*)
Cottonwood (*Populus deltoides*)
Choke cherry (*Prunus melanocarpa*)
Wild grape (*Vitis* sp.)
Hackberry (*Celtis occidentalis*)
Ash (*Fraxinus* sp.)
Wild plum (*Prunus americana*)
Sand cherry (*P. besseyi*)
Black locust (*Robinia pseudo-acacia*)
Lead plant (*Amorpha canescens*)
Ragweed (*Ambrosia* sp.)
Sunflower (*Helianthus* sp.)

Small stands of hackberry, cottonwood, choke cherry and wild plum occur natively. The last two mentioned species are commonly found forming thickets of shrubs or small trees, often associated with buckbrush, wild rose, and the shrubby sandhill willow.

Descriptions of several browse study plots, given elsewhere in this paper (page 151), present further and somewhat detailed information on the character of the deer range in Nebraska National Forest.

THE DEER HERD

Mule deer were probably resident in the vicinity of the Bessey Division at the time of its inception in 1902. The first recorded reference to their occurrence in the reserve is a Forest Service report of a herd of eight in 1914. Total protection was accorded the deer in this situation by virtue of a statewide closed season and a state law which declares the entire National Forest to be "a game reserve, bird refuge and wild fowl sanctuary." The annual planting of various kinds of evergreens and the consequent development of suitable cover, and the protection to native woody plants afforded by the system of restricted grazing by livestock, have probably combined to make some improvement in the forest area as deer range. Consistent increases in the number of deer on the Forest have apparently occurred in response to these conditions (Mohler, 1944). It must be noted, however, that populations of mule deer in other parts of Nebraska have shown remarkable increases in the last twenty years—to the extent, in fact, that in 1949 the Game, Forestation and Parks Commission issued 1,500 deer hunting permits. The area opened to hunting included Morrill, Scotts Bluff, Sioux, and Dawes counties, and the part of Sheridan County north of the Niobrara River. Observers in northwest Nebraska frequently saw a hundred or more deer in a single day afield by the fall of 1949. Damage to agricultural crops, and highway mortalities of deer,

had become common in all of these counties and were also occurring in many other parts of the state.

A review of available records by Rasmussen and McKean (1945) showed estimated numbers of deer on the Bessey Division to be as follows:

Year	*Number*	*Basis for numbers*
1914	8	Ocular estimate
1920	15–20	Ocular estimate
1925	40–50	Ocular estimate
1930	96	Ocular estimate
1935	189	Ocular estimate
1936	264	Spot counts
1938	382	Spot counts
1940	630	Spot counts
1944	850	Aerial sample

Forest Service estimates for recent years follow:

Year	*Number*
1946	300
1947	300
1948	320
1949	325

The marked increase in numbers of deer by the late 30's, with the accompanying damage to plantations evidenced by the high-lining of the larger trees and the hedging of the smaller ones, caused some concern to Forest Service personnel. Rasmussen and McKean (1945) wrote of this as follows: "The problem of the over-abundance of deer on the area was recognized by R. E. Clark and T. Krueger of the Denver office of the U. S. Forest Service as shown in their report on an inspection visit during the period of April 29 to May 8, 1941. They report damage to existing plantations, especially red cedar and hardwoods, and suggested a definite study of the situation, and need for establishment of a definite game management plan. They also expressed concern about the deer becoming a serious problem within the next ten years. This was not in agreement with the opinion of other men well acquainted with the area, but subsequent events have shown even they were optimistic. Their prediction of a deer problem materialized in less than half the time they allowed."

Mohler, who has been doing some field work on the forest from 1941 to the present in connection with investigations on sharp-tailed grouse and other upland game birds, made mention of deer as follows in a weekly report to Game Commission headquarters dated November 9, 1942: ". . . saw 10 deer one day and 76 the next. . . Ranger Hester and I examined some of the browse, and he emphasized that the forest will soon have a deer problem since browse is comparatively scarce and the deer herd is now at the point where it will increase rapidly. He says there are several hundred, maybe even a thousand, in the forest alone." Forest Supervisor Dayharsh at that time was anxious to have state game officials come to the forest, ". . . in the fall when deer can be seen, so the game department can understand what is approaching on the National Forest."

Rasmussen and McKean made no attempt to determine total numbers during their 1944 visit to the area, but they wrote that "Deer were seen over the entire area and were very abundant as judged by visits the investigators have made to mule deer ranges in other western states."

Early investigations relative to the deer problem on Nebraska National Forest were confined mainly to general observations on deer and range relationships, and to examination of deer damage to nursery and forest planta-

tions (Plates 7 and 8) by Forest Service personnel. From October 1942 to December 1944, R. R. Hill examined the contents of 22 stomachs from mule deer killed by highway, railroad, and miscellaneous accidents. About 29 deer were ear-tagged in 1944 and 1945 at the Bessey Nursery as an aid to learning something about deer movements, longevity, etc. In March 1944 an aerial survey of the Bessey Division was made by Roy N. Bach of the North Dakota State Game and Fish Department, assisted by R. R. Hill, then Supervisor of the Nebraska National Forest, and Mohler. This was followed by field investigations on the Forest during the week of October 9–14, 1944, by D. I. Rasmussen of the Utah Cooperative Wildlife Research Unit and William T. McKean, leader of the Black Hills deer investigation project for the South Dakota Game, Fish and Parks Commission.

All evidence gathered indicated that the area was overstocked with mule deer and that there was need of removal of not less than 300 animals in the immediate future. Rasmussen and McKean (1944) recommended that the harvesting of surplus deer be done by means of a supervised hunt under a special permit system.

In 1945 legislative action authorized deer hunting in the Forest reserve; a hunt was scheduled for December 1–21, 1945. It then appeared desirable to obtain herd data immediately prior to and following the hunt. Wampole spent much of September, October, and November 1945 on the Forest obtaining information on (1) the number of deer on the area, (2) the sex ratio, (3) the old-young ratio, (4) areas of deer occupancy, and (5) the breeding season.

PRE-HUNT HERD DATA

In 370 miles of driving and walking, mostly during early morning, late afternoon, and evening hours, 313 deer were seen. This number amounts to one deer seen for every 1.2 miles of travel. All deer seen were apparently mule deer.

Sex Ratio of Adult Deer. Of the 313 deer seen (the sample herd), 53 were antlered and considered to be bucks. Of the antlerless deer seen, 110 were considered to be does. A ratio of one buck to two does was indicated. Seventy other antlerless deer were seen, but under conditions precluding reliable differentiation between does and large fawns. The ratio of adult bucks (53) to all other deer seen (258) was 1:5.

Old-young Ratio. The ratio of adults (163) to young (78) was about 2:1. Seventy-eight fawns and 110 does were seen, a ratio of 71 fawns per 100 does. Fifty-nine does apparently without fawns were seen. Forty-three does were accompanied by one fawn each; eight does were seen with twins. Fifteen fawns were seen apparently not in company with does.

Areas of Deer Occupancy. The routes followed were considered as fairly sampling the areas of dense and open timber and grassland.

During the three-month period, 140 deer, 45% of the sample herd, were seen in densely timbered areas. This varied from 10% the last days of August to 57% in November and indicated a tendency of the deer to locate in the heavier timber as winter approached.

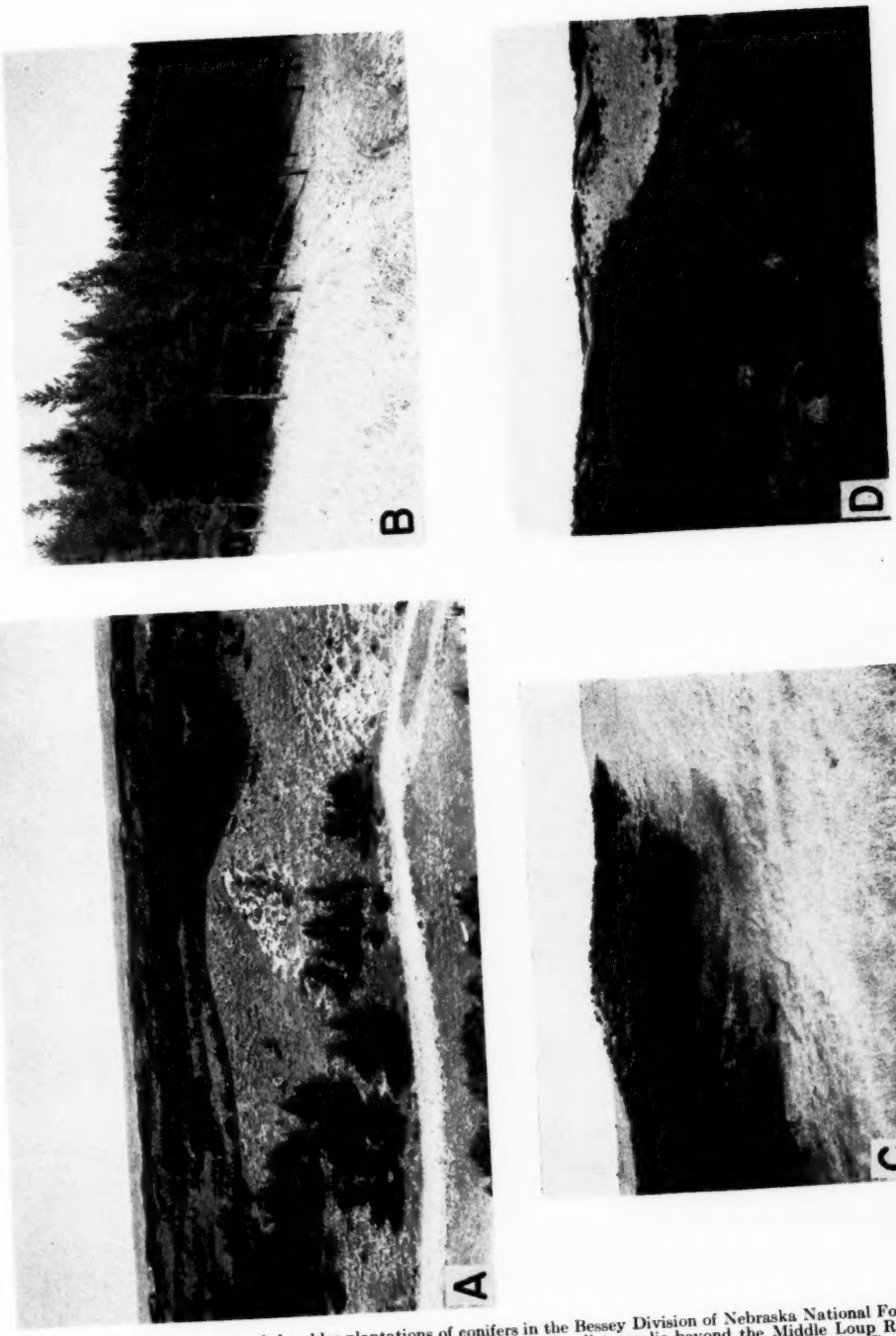

PLATE 5. A.—View of some of the older plantations of conifers in the Bessey Division of Nebraska National Forest, looking north from Scott Lookout Tower. The unforested hills in the distance lie beyond the Middle Loup River. Photo U. S. Forest Service, July 7, 1945. B.—Jack pine plantation in Nebraska National Forest, Thomas County. These trees are about 40 years old. Photo by Louis Moos, November, 1949. C.—Young plantation of red cedar in Nebraska National Forest, Thomas County. A thicket of wild plum can be seen in the pocket in the center of the picture. Photo by Louis Moos, November, 1949. D.—Plantation of red cedar in Nebraska National Forest, Thomas County. The height of these young trees is indicated by the fence posts across the middle of the picture. Photo by Louis Moos, November, 1949.

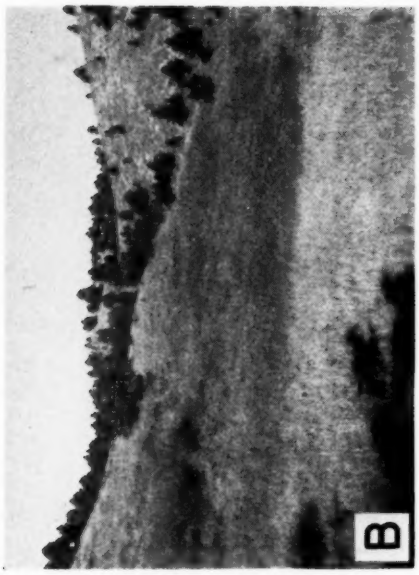

PLATE 6. A.—A thicket of native wild plum in an open stand of ponderosa pine, Nebraska National Forest, Thomas County. Note the abundance of prairie grasses. B.—A thicket of buckbrush, the most important browse species for mule deer in Nebraska National Forest, occupies the pocket and slope in the center of the picture; a small amount of wild plum occurs on the slope to the left. C.—View of browse study Plot No. 10, Nebraska National Forest, Thomas County. Below the road which crosses the background, is seen a thicket of choke cherry associated with two large and ten small hackberry trees. On this side of the choke cherry is a buckbrush thicket and in the foreground a good stand of sunflowers. D.—Deer line on Scotch pines in Nebraska National Forest, Thomas County. Photos by Louis Moos, November, 1949.

PLATE 7. A.—Damage to red cedars by mule deer in the nursery area, Bessey Division, Nebraska National Forest. About 1944. B.—Deer line on Scotch pines in Nebraska National Forest, Thomas County. Photo by Levi Mohler, November, 1949.

PLATE 8. A and B.—Severe damage to Scotch pine plantation in Nebraska National Forest, Thomas County, March, 1940. Photos by U. S. Forest Service.

In the open timber during the same period 52% of the herd was seen. The percentages varied from 68 in August through 90 and 60 in September and October, respectively, to 40 in November. In the open grassland areas the percentages were 10, 1 and 3 for September, October, and November, respectively.

The Breeding Season. With two exceptions all adult deer seen before October 30 appeared to be segregated by sexes; a buck and a doe were seen together on August 29 and another pair was seen on October 1. Some antlers seen in September were still in the velvet. Swollen necks were noticed on bucks for the first time on October 29. On October 31 a buck, two fawns, and a doe were seen together. During November there was considerable evidence of harems being acquired. No combat between bucks was noted except for a little "sparring" on the part of two. On November 20 a rancher found a dead 4-point buck near the Forest boundary; there was evidence of antler and hoof damage, some of the antler thrusts having pierced the chest cavity. Apparently the breeding season starts in October and continues through November. Data obtained during the hunt (presented later in this paper) indicate that the breeding season extends into December.

HUNTING DATA

In keeping with the decision to attempt the removal of between 300 and 400 deer, 500 deer hunting permits were issued. Each permittee was entitled to take one deer of either sex. Applications for permits were received from 998 persons and the 500 permittees were selected at a public drawing more than three months before the hunt; 448 of the permittees actually hunted. The known kill was 361 deer; this total includes 11 deer found dead, retrieved as cripples, or confiscated.

Before the season opened 455 permittees returned cards indicating their choices of hunting dates. Following receipt of these cards, and before the season opened, all permittees were notified that they could hunt at any time during the 21-day season regardless of the dates given on the cards. Two hundred and five permittees indicated that they wished to hunt on opening day; checking station records showed that 192 did hunt then. Chronological distribution of the numbers hunting throughout the 21-day season are shown in Table 1.

TABLE 1.—NUMBER OF DEER HUNTERS HUNTING

Date	Number hunting
Dec. 1	192
2	90
3	49
4	31
5	39
6	56
7	39
8	58
9	72
10	62
11	54
12	49
13	39
14	23
15	23
16	14
17	11
18*	4
19	7
20	13
21	14

*December 18 was the only day of the season on which no new hunter came into the area.

Weather Conditions. Several weeks of dry weather preceded the hunt and there

was some concern about the fire hazard. The day before the hunt opened was notable for clear skies and spring-like temperatures. By the following morning, however, several inches of snow were on the ground and a blizzard was in progress. Although the storm made hunting "rough" the first day, the fire hazard was reduced and good tracking conditions were available on subsequent days.

Sighting-in Range. Life-size deer targets were arranged on a conveniently located practice range near the hunting camp. Most hunters were anxious to test their sights and the range was kept busy especially on the day preceding opening day. There were instances wherein hunters neglected to sight in their guns, subsequently missed numerous shots at deer, and later returned to the practice range to correct their troubles. The range definitely made a hit with the sportsmen and probably contributed to the high success of the hunt.

Hunting Success. Seventy-eight per cent of those hunting (350 of 448) succeeded in taking deer. Successful hunters came from 76 of the 93 counties in Nebraska. About 30 per cent of the deer were taken by persons living within a 70-mile radius of the forest.

Hunting data and biological data were taken at a checking station located on the main road to the hunting area. Hunting data were not taken from hunters who failed to bag deer.

Three hundred and twenty-four permittees came into the Forest during the first week and 248 deer were taken in that period; 106 additional permittees came the second week, during which time 89 deer were taken; 18 more permittees came the third week and 24 deer were taken then. Some of the deer killed during the last two weeks were, of course, killed by hunters who had first come in during the previous week.

Successful hunters used from one to six days for their hunting. Two hundred and seven hunters used one day only; 81 used two days; 44 used three days; 13 used four days; 4 used five days; 1 used six days. Total hunting time by successful hunters increased from 4.0 hours in the first week to 4.8 hours in the second week and 4.9 hours in the third week. Hunters used from a few minutes to nine hours of hunting time on the day when they actually killed their deer. The average was 3.2 hours of hunting on the day of the kill, but on the first and second days of the season only 2.7 and 2.9 hours were required, respectively.

Regulations permitted shooting between 8:00 A.M. and 5:30 P.M. The kill by hours is shown in Table 2.

More bucks were killed in the first two hours of the day than at any other two-hour period; the doe kill reached a peak in late afternoon. This difference may be due partly to differences in the habits of the two sexes of adult deer, or it may reflect hunter habits and hunter psychology. It appears, nevertheless, that chances of bagging a buck may be better in the morning than in the afternoon. The fawn-take pattern by hours was quite similar to that for does, which might be expected since fawns at six months of age are often in company with the does.

Area Per Hunter. The area open to hunting allowed over 450 acres per hunter on opening day, 1000 acres per hunter on the second day, 1,250 acres per hunter on the second Sunday and

TABLE 2.—DEER KILL BY HOURS

Hour	Yearling and older deer		Fawns		Totals	Per cent of total
	Bucks	Does	Bucks	Does		
8–9	17	20	7	2	46	13.5
9–10	24	20	1	5	50	14.7
10–11	12	18	4	2	36	10.6
11–12	13	23	3	4	43	12.6
12–1	9	10	3	1	23	6.8
1–2	8	12	2	4	26	7.6
2–3	8	14	3	3	28	8.2
3–4	14	16	2	3	35	10.3
4–5	9	27	3	5	44	12.9
5–5:30	3	4	1	1	9	2.6
Totals	117	164	29	30	340*	

*Time of kill not known for remaining 21 deer

1,500 acres or more per hunter on all other days. Hunters were not assigned to individual areas. There were no hunting accidents.

The take in the area open to hunting averaged about 2.6 deer per section. The kill was higher in the timbered areas and lower in the open grassland. More deer were taken in the northwestern, northern, central, and southeastern parts of the timbered area than elsewhere. These are all areas in which deer were seen in good numbers before the hunt. Observations indicate that the same areas still harbor most of the deer in the post-hunting period.

Table 3 shows the percentage of fawns, bucks, and does taken in four types of cover. The main differences noted in the sexes in the table are the larger percentage of does taken in the timber and the larger percentage of bucks taken in the open grassland.

Less than a third of the deer were shot in open grassland, and many of these near timber, even though more than two-thirds of the hunting area consisted of open grassland. There is little brush in the forest proper. Open timber seems to be the preferred habitat for the mule deer in this situation.

Activity of Deer When Shot. Data concerning activity of the deer when shot are shown in Table 4. Standing deer of both sexes made up a higher percentage of the kill on opening day than later in the season. A total of seven deer were shot while lying down, but these seven included no fawns.

It was the opinion of the checking crew, the conservation officers, and the hunters that the crippling loss in this hunt was very low. Thirty-one per cent of the hunters taking bucks and 41 per cent of the hunters taking does (a total of 120 different hunters) shot

TABLE 3.—PER CENT OF FAWNS, BUCKS, AND DOES TAKEN IN EACH COVER TYPE

Number of deer	Grassland	Brush	Open Timber	Heavy Timber
Fawns 53	28	6	45	21
Bucks 118	32	4	43	21
Does 171	25	3	46	26
Totals 342	28	3	45	24

TABLE 4.—ACTIVITY OF DEER WHEN SHOT* (Shown as per cent)

Activity	First day of season			Remainder of season			Entire season		
	Males	Females	All deer	Males	Females	All deer	Males	Females	All deer
Standing	70	67	68	60	59	59	63	62	62
Running	22	18	20	28	31	30	26	27	27
Walking	6	11	9	9	9	9	8	10	9
Lying down	2	4	3	3	1	2	3	1	2

*Based on 346 deer, including fawns

at and missed one or more deer. Some of these "missed" deer were probably actually hit. Only eleven hunters reported shooting at and missing more than three deer apiece. The average for all who admitted to missing a deer was about two deer per hunter, but 70 per cent of those missing a deer missed only one deer.

Deer Seen By Hunters. Individual hunters saw an average of about seven deer on opening day, six per day for the entire first week, four per day in the second week, and three per day in the third week. It seems probable that the smaller number seen in late season was due partly to the actual decrease in the numbers of deer and partly to greater wildness in the remaining deer.

Other Hunters Seen. Successful hunters saw an average of about 15 other hunters while hunting on opening day, about 11 other hunters on the second day, and six or less on all other days. Table 5 shows these data for the entire season.

Guns Used. Twenty-six different types of guns were used in killing deer. The seven listed in Table 6 took 85 per cent of the deer and none of the other 19 types of guns made more than two per cent of the kills.

Length of Shots. Most of the hunters estimated the length of their killing shots; a few paced off the distance. Table 7 summarizes the data on length of shots, including estimated as well as paced distances.

Other hunting data, including percent of deer dropped in their tracks by various guns, distance travelled by deer after being hit, and an analysis of the effectiveness of various body shots, have been published elsewhere (Mohler, 1946).

TABLE 5.—OTHER HUNTERS SEEN BY SUCCESSFUL HUNTERS WHILE HUNTING

Date*	Average number of other hunters seen	Date	Average number of other hunters seen	Date	Average number of other hunters seen
1	15	8	5	15	2
2	11	9	5	16	5
3	5	10	4	17	2
4	6	11	6	18	1
5	5	12	5	19	1
6	6	13	1–	20	2
7	3	14	1–	21	2
First week	11	Second week	5	Third week	3

*All dates December 1945

TABLE 6.—PER CENT OF TOTAL KILL BY VARIOUS GUNS

Gun used	Number of deer taken	Per cent of total kill
30–30	114	33
30–06	76	22
30–40 Krag	27	8
250–3000	25	7
25–35	21	6
300 Savage	19	5
35	13	4
All others*	52	15
Totals	347	100

*Shotguns using slugs killed six deer.

TABLE 7.—LENGTH OF SHOTS (Averages in yards)

	First Day	Remainder of season	Entire Season
Bucks			
Yearling or older	93	162	138
Fawns	125	140	137
All bucks	96	156	138
Does			
Yearling or older	98	166	147
Fawns	92	102	99
All does	97	156	139
Sexes Combined			
Yearling or older	96	164	143
Fawns	102	122	117
All deer	97	156	139*

*While the average was 139 yards the median was about 100 yards.

BIOLOGICAL DATA FROM THE CHECKING STATION

All of the deer taken were brought to the checking station. The kill by days, together with sex and age data, is shown in Table 8.

Table 9 contains further breakdown of the age data. Age classifications, in deer older than fawns, were made according to dentition. Size alone served to distinguish fawns from older deer. Deer having third premolars with three cusps were classified as yearlings (1½ yrs. in tabulations). Deer having new, and usually practically unstained, permanent (2-cusped) third premolars were classified as 2½ year-olds. Amount of wear was used as the criterion in placing 3½-year-olds and older deer in the various age-classes. We recognize that the chances of some error in aging older deer are considerable, and no claims for infallibility are made for the aging reported here. However, since this herd had not been previously hunted and hence undoubtedly contained many rather old deer, it seemed desirable to attempt some breakdown of age data beyond the younger classes.

Weights. The deer were weighed on balanced platform scales at the checking station. Average weights of the hog-dressed mule deer are shown in Table 10.

The heaviest buck, classes as 8½ years old, dressed out at 196½ pounds. The heaviest mule deer doe, classed as 9½ years old, dressed out at 122 pounds. Average weights among does changed

very little after passing the 2½-year-old class. With the exception of one age class, average weights of bucks increased rather evenly up to the 7½-year-old class.

Antler Measurements. Antler measurements, including spread, inside length, and circumference one inch above the burr were taken on all antlered deer. Data from these three measurements from normally developed antlers in the various age classes are shown in Tables 11, 12, and 13.

Variations in measurements were considerable within each age class, but on the basis of these data it appears that mule deer antlers typically show rapid increases in size in successive age classes up to the fourth year, smaller increases during the next three years, and generally small changes after the seventh year.

Antler Points. The number of points one inch or more in length ranged from 1 x 1 to 5 x 7 on normally developed sets of antlers. Table 14 summarizes the antler point data according to age classes.

Mature bucks commonly had four points on each antler, exclusive of brow tines. The point combination next in frequency among mature bucks was 3 x 4. Antler points exceeding 4 x 4 in number were found only on deer 4½ years old or older. Sixty-three per cent of the normal sets of antlers had the same number of points on both antlers; 37 per cent had unlike numbers of points on the two antlers.

Antlers which were not considered normal in development included a set of dwarf spikes only 2 and 3 inches long, a malformed set on a senile deer, a 1 x 2 point set on a 4½-year-old buck, a short "cauliflower" or freak set on an 8½-year-old buck, and a grotesque set on a 7½-year-old buck. The latter three sets of antlers were all in the velvet and the testes of the deer bearing them were exceptionally small.

Antlered Does. A dry doe, 3½ years old and weighing 100 pounds, hog-dressed, had a half-inch button on the right side. A wet doe, 6½ years old and weighing 103 pounds, had one velvet spike antler about 8 inches long. Another wet doe, 6½ years old and weighing 94 pounds, had a small forked velvet antler on the left and a small knob on the right.

Hind Foot Measurements. Hind feet of deer were measured for length with results as shown in Tables 15 and 16. The averages were higher for bucks than does in all age classes.

Swollen Necks on Bucks. The peak of the breeding season for mule deer in the Rocky Mountains is ordinarily considered to be in late November and early December (Chattin 1948, Robinette and Olsen 1944). Bucks normally show swollen necks during the breeding season. Presence or absence of swollen neck was recorded for most of the male deer taken during the hunt. No buck fawns had swollen necks. Sixty per cent (6 of 10) of the yearlings had swollen necks; 89 per cent (8 of 9) of the 2½-year-olds had swollen necks; 95 per cent (70 of 74) of those 3½ years old or over had swollen necks.

Wet Does. December may be a bit late to determine accurately by teat and udder examination whether or not a doe nursed young during the past rearing season. However, milk was present in many does and definitely lacking in others. Forty-one per cent

TABLE 8.—SEXES AND AGE CLASSES OF DEER KILLED DURING 1945 SEASON

Date	Sex	½	1½	2½	3½	4½	5½	6½ & over	Males	Females	Totals
1	M	5	10	5	5	5	3	17	50		
	F	9	10	12	7	2	1	18		59	109
2	M	4	3	0	0	1	2	7	17		
	F	2	1	9	3	2	3	7		27	44
3	M	0	3	1	3	2	2	5	16		
	F	2	2	1	1	0	2	1		9	25
4	M	5	0	1	3	0	0	2	11		
	F	0	3	5	4	2	0	1		15	26
5	M	0	1	0	1	1	1	1	5		
	F	1	1	1	1	1	2	1		9*	14
6	M	3	0	0	0	1	0	3	7		
	F	2	0	2	1	3	1	0		9	16
7	M	0	1	2	1	2	1	3	10		
	F	0	0	1	0	2	0	1		4	14
8	M	1	0	1	0	1	0	6	9		
	F	4	1	2	0	1	1	2		11	20
9	M	2	0	0	0	0	0	0	2		
	F	4	2	2	5	3	1	0		17	19
10	M	3	0	1	1	2	0	2	9		
	F	2	0	1	1	1	1	0		6	15
11	M	0	0	0	0	2	0	0	2		
	F	0	1	1	2	1	0	1		6	8
12	M	1	0	0	1	0	0	1	3		
	F	1	1	4	1	0	0	0		7	10
13	M	1	0	0	0	0	0	1	2		
	F	0	2	1	1	0	1	1		6	8
14	M	0	0	0	0	0	0	0	0		
	F	1	3	2	2	0	0	1		9	9
15	M	0	0	0	0	0	0	2	2		
	F	0	0	0	1	0	0	0		1	3
16	M	2	0	1	0	0	0	1	4		
	F	0	0	0	0	2	0	0		2	6
17	M	1	0	1	0	0	0	0	2		
	F	0	0	1	0	0	0	0		1	3
18	M	0	0	0	0	0	0	0	0		
	F	0	0	0	0	0	0	0		0	0
19	M	0	0	0	0	0	0	0	0		
	F	1	0	0	0	0	0	0		1	1
20	M	1	0	0	0	1	0	0	2		
	F	1	0	0	1	1	0	1		4	6
21	M	1	0	0	0	0	0	0	1		
	F	1	0	0	1	1	0	1		4	5
Total	M	30	18	13	15	18	9	51	154		
	F	31	27	45	32	22	13	36		207*	
										Grand Total	361

*One adult doe of unknown age taken on December 5.

TABLE 9.—SEXES AND AGE CLASSES OF DEER KILLED DURING 1945 SEASON

Age	½	1½	2½	3½	4½	5½	6½	7½	8½	9½	10½	11½ & up
Bucks	30	18	13	15	18	9	17	13	8	5	3	5
Does*	31	27	45	32	22	13	12	3	9	2	4	6
Total	61	45	58	47	40	22	29	16	17	7	7	11
Percent of total	16.9	12.5	16.1	13.1	11.1	6.1	8.1	4.5	4.7	1.9	1.9	3.1

*Table based on 360 deer, omitting one doe of unknown age.

TABLE 10.—MULE DEER WEIGHTS (hog-dressed)

Bucks			Does	
Number weighed	Average weight	Age	Number weighed	Average weight
30	49.4 lbs.	½	28	46.0 lbs.
18	91.1 lbs.	1½	26	81.5 lbs.
13	107.0 lbs.	2½	44	94.8 lbs.
15	130.6 lbs.	3½	30	93.9 lbs.
18	141.4 lbs.	4½	22	94.9 lbs.
9	155.1 lbs.	5½	13	98.0 lbs.
16	150.2 lbs.	6½	12	95.8 lbs.
13	167.3 lbs.	7½	3	105.3 lbs.
7	167.8 lbs.	8½	9	92.9 lbs.
5	166.0 lbs.	9½	2	112.7 lbs.
3	172.1 lbs.	10½	4	93.6 lbs.
5	149.1 lbs.	11½ or over	6	99.0 lbs.

TABLE 11.—ANTLER SPREAD (in inches)

Age class	Number of deer measured	Minimum	Maximum	Average
1½	18	7.25	14.50	9.72
2½	12	9.50	18.25	15.22
3½	14	14.50	24.00	18.52
4½	16	16.75	26.50	21.23
5½	9	19.00	29.75	22.77
6½	17	17.87	30.75	22.63
7½	12	19.50	27.50	23.92
8½	7	20.25	26.50	23.07
9½	5	22.00	32.12	25.39
10½	3	18.00	26.00	22.66
12½ or over	4	19.00	27.75	22.93

of the does 2½ years old or older were wet. All yearling does were dry. Table 17 indicates a higher percentage of productive does among 4½-, 5½-, and 6½-year-olds than among either younger or older does. If December determinations are accurate it would seem that the herd contained more dry does than would be expected.

The percentage of wet does was lower than noted in the Black Hills of South Dakota, where a check of 36 white-tailed does and 10 mule deer does in January 1944 showed that 50 per cent of each group consisted of wet does. In the Black Hills in November of 1945 and previous years a check of 29 white-tailed does and 10 mule deer does

TABLE 12.—ANTLER LENGTH (inside, in inches)

Age class	Number of deer measured	Minimum	Maximum	Average
½	1	*	1.00	*
1½	17	6.00	14.50	9.61
2½	12	9.50	15.75	13.50
3½	14	14.25	21.00	17.60
4½	17	16.25	24.25	19.75
5½	9	19.00	24.50	21.10
6½	17	18.00	25.50	21.31
7½	12	19.00	26.50	21.83
8½	7	20.00	24.25	21.75
9½	5	21.50	25.00	22.81
10½	3	20.00	24.00	22.25
12½ or over	4	18.50	23.00	21.28

*Most buck fawns had only buttons or "nubbins" less than one inch long. These were not measured.

TABLE 13.—ANTLER CIRCUMFERENCE (one inch above burr; in inches)

Age class	Number of deer measured	Minimum	Maximum	Average
1½	18	1.62	3.00	2.27
2½	12	2.37	3.87	3.02
3½	15	2.87	4.37	3.64
4½	17	2.62	5.25	3.93
5½	8	4.00	4.75	4.28
6½	17	3.75	5.12	4.49
7½	11	4.12	5.50	4.79
8½	7	4.12	5.12	4.72
9½	5	4.00	5.37	4.68
10½	3	4.50	4.87	4.62
12½ or over	4	4.50	5.50	4.89

TABLE 14.—ANTLER POINTS ONE INCH OR MORE IN LENGTH, EXCLUDING BROW TINES, IN RELATION TO AGE

Number points	1x1	1x2	2x2	2x3	3x3	3x4	3x5	4x4	4x5	4x6	5x6	5x7
Age												
1½	5	2	9	2								
2½			3		4	3		2				
3½			1		1	2		10				
4½				1	2	6		5			2	
5½							1	5	2			
6½			1	1		1		11	2	1		
7½					2	3	2	4			1	
8½				1				4	1			1
9½						1		2	1	1		
10½			1						1		1	
12½ or over						1	1	2	1			
Totals	5	2	15	5	9	17	4	45	8	2	4	1

showed 82.6 per cent and 70 per cent wet does, respectively.*

*This information in a letter dated April 3, 1946, from William T. McKean, at that time Leader, Big Game Survey, South Dakota Department of Game, Fish, and Parks, to Mohler. Courtesy of Mr. McKean and the South Dakota Department.

Condition of the Deer. Based largely upon manual examination of various parts of the carcass, and on general appearance, the deer were classified as fat, good, fair, or poor. Forest Service personnel assisting at the checking station were of the opinion that the

TABLE 15.—HIND FOOT LENGTH (in inches), MULE DEER BUCKS.

Age	Number deer measured	Minimum	Maximum	Average
½	30	15.50	17.37	16.12
1½	18	17.00	19.50	18.21
2½	13	17.50	19.00	18.55
3½	15	17.87	19.75	18.88
4½	18	18.25	19.62	18.88
5½	9	18.00	19.75	18.80
6½	16	17.75	20.00	18.75
7½	13	18.00	19.50	18.94
8½	8	18.00	20.00	19.28
9½	5	18.62	19.50	19.17
10½	3	18.37	20.00	19.54
12½ or over	5	18.50	20.00	19.00

TABLE 16.—HIND FOOT LENGTH (in inches), MULE DEER DOES.

Age	Number deer measured	Minimum	Maximum	Average
½	29	13.50	17.75	15.64
1½	27	16.50	18.50	17.56
2½	45	16.00	18.75	17.76
3½	29	17.00	18.50	17.87
4½	22	16.25	18.50	17.77
5½	13	16.75	18.50	17.88
6½	12	17.00	18.25	17.64
7½	3	17.25	18.25	17.66
8½	9	17.00	18.75	17.61
9½	1	18.25	18.25	18.25
10½	4	17.00	18.00	17.50
11½ or over	5	17.50	18.00	17.85

TABLE 17.—PER CENT WET AND DRY DOES OF VARIOUS AGE CLASSES

Age class (by teeth)	Wet		Dry		Total no. checked
	Number	Per cent	Number	Per cent	
2½ years	15	39	23	61	38
3½ years	9	35	17	65	26
4½ years	9	45	11	55	20
5½ years	6	60	4	40	10
6½ years	4	44	5	56	9
7½ & older*	8	38	13	62	21
Totals	51	41	73	59	124

*Includes one wet doe of unknown age.

deer were not as fat as deer usually taken in Black Hills or Colorado hunts, and Table 18 shows comparatively few fat deer.

Ear-tagged Deer Shot. At least 29 deer were trapped and ear-tagged by Forest Service personnel near headquarters in the two years preceding the hunt. Four of these deer were taken by hunters. All deer were examined for tags at the checking station and there could have been only a very slight chance that other ear-tagged deer could have been missed by the checkers. It was hoped

TABLE 18.—CONDITION OF DEER

	Number classified	Fat		Good		Fair		Poor	
		No. deer	Per cent	No. deer	Per cent	No. deer	Per cent	No. deer	Per cent
Males	152	5	3.3	100	65.8	45	29.6	2	1.3
Females	198	25	12.6	137	69.2	35	17.7	1	0.5
Totals	350	30	8.6	237	67.7	80	22.8	3	0.9

that the combined ear-tagging and subsequent hunting might be useful as a census technique, but the significance of the small take of tagged deer is not understood. Although only about 14 percent of the ear-tagged deer were killed it is believed that the herd harvest was greater than that.

White-tailed Deer. Excepting for southern and eastern areas most of Nebraska's deer are Rocky Mountain mule deer. Two white-tailed deer were taken in the 1945 hunt. One was a wet doe 2½ or 3½ years old, which weighed 109 pounds hog-dressed. The hind feet measured 19.25 inches. The other, a dry doe 3½ years old, weighed 134½ pounds hog-dressed; the hind feet measured 20.25 inches. The latter doe was the heaviest female taken in the entire hunt. Freshly shed antlers from a white-tailed buck were found and brought to the checking station by a hunter on December 14.

LABORATORY FINDINGS

Parasites. Limited examinations of deer carcasses at the checking station during the first week of the hunt revealed what appeared to be a rather low incidence of parasites. The intestinal tracts of 20 deer were examined; the cestode *Moniezia benedeni* (Moniez, 1879) was found in low numbers in the small intestine of two of the deer. The duodenum of a third deer contained two specimens of *Thysanosoma actinoides* Diesing, a cestode known to inhabit the bile duct and intestine of sheep.

The urinary bladders and livers of three deer were examined. One liver contained a cyst; similar cysts were found on the urinary bladder and rectum of a second deer, and on the mesenteries of a third. These parasitic forms are best reported here as unidentified cysticerci.

One specimen of the nematode *Setaria cervi* (Rudolphi, 1819) was found free on the cut end of a leg muscle near the abdominal cavity immediately after the deer, a half-year old male fawn, had been hog-dressed. It is reasonably safe to assume that this worm had been in the abdominal cavity, in which site in cattle it is known to occur.

The lungs of eight deer showed no indication of the presence of parasites. No evidence of foot worm disease was found although the feet of several deer were carefully examined.

The heads of seven deer were cut open to allow thorough inspection of the nasopharyngeal cavities. Immature larvae of the cuterebrid fly *Cephenomyia pratti* Hunter were found in two cases. Specimens of the same maggot had previously (1944) been found in deer of this herd by Forest Service personnel.

Examination of many freshly killed deer yielded small numbers of the mallophagan *Trichodectes* sp., the only ectoparasite found.

Stomach Analyses. Stomach samples from 78 mule deer, secured on or in the immediate vicinity of the Bessey Division of Nebraska National Forest, have been examined; most of the analyses have been made by Ralph R. Hill and Fichter. Fifty-three of these stomach samples were collected during the hunt in December 1945; the remaining 25 were taken during the period November 1943 to March 1947 from animals which were, for the most part, highway and railroad casualties. The values thus secured relative to the feeding habits of deer in this area, presented in Table 19, largely represent winter conditions. The lack of summer samples is unfortunate. The relatively few samples taken in spring and autumn offer data considered inadequate for conclusive analysis. Certain indications are suggested, however.

(1) The marked importance of buckbrush, jack pine, wild rose, and sunflower in the diet of mule deer

TABLE 19.—FOOD ITEMS FOUND IN STOMACH SAMPLES FROM MULE DEER TAKEN ON OR IN THE IMMEDIATE VICINITY OF NEBRASKA NATIONAL FOREST, BESSEY DIVISION.

	SPRING Mar.–May 9 (7 samples)		AUTUMN Aug. 10 to Oct. 30 (7 samples)		WINTER Nov. 15 to Feb. 16 (64 samples)		All samples (78)	
	% of tot. vol.	Freq. %	% of tot. vol.	Freq. %	% of tot. vol.	Freq. %	% of tot. vol.	Freq. %
Buckbrush (*Symphoricarpos occidentalis*)	5.7	42.9	4.6	28.6	25.1	73.4	21.5	66.6
Wild Rose (*Rosa* sp.)	7.6	57.1	33.3	85.8	10.4	71.9	12.2	70.5
Redroot (*Ceanothus ovatus*)	–*	14.3	20.7	28.6	0.6	14.1	2.4	15.4
Chokecherry and wild plum (*Prunus* spp.)	6.0	28.6	7.7	28.6	0.9	9.4	4.0	14.1
Poison Ivy (*Rhus toxicodendron*)	0.7	14.3	–	–	0.9	34.4	0.8	29.5
Willow (*Salix* sp.)	6.9	28.6	–	14.3	0.2	4.7	0.8	7.7
Jack pine (*Pinus banksiana*)	7.9	28.6	–	14.3	18.4	67.2	15.8	59.0
Ponderosa pine (*Pinus ponderosa*)	2.9	14.3	–	–	2.3	12.5	2.1	11.5
Scotch pine (*Pinus sylvestris*)	–	–	–	–	0.8	1.6	0.6	1.3
Unidentified pine	–	14.3	2.3	14.3	0.3	6.3	0.5	7.7
Juniper or red cedar (*Juniperus* sp.)	7.1	14.3	0.6	14.3	1.5	20.3	2.0	19.2
Soapweed (*Yucca glauca*)	7.1	14.3	1.4	14.3	2.0	53.1	2.4	47.4
Prickly pear (*Opuntia* sp.)	–	–	3.6	14.3	0.2	12.5	0.5	11.5
Sunflower (*Helianthus* spp.)	1.4	57.1	–	–	12.1	70.3	10.1	62.8
Miscellaneous grasses and sedges	33.7	100.0	6.1	85.8	3.0	64.1**	6.0	69.2***
Unidentified seeds, buds, and leaves and miscellaneous minor known items	13.0	****	19.7	****	20.9	****	20.0	****
Fungi	–	–	–	–	0.4	12.5	0.3	10.3

*Trace occurrences
**85.4% of these were trace occurrences
***74.1% of these were trace occurrences
****Frequency percentages for lumped items (excepting grasses and sedges) not considered significant

in the area reported here is evidenced by both percentage of total volume and percentage frequency of occurrence, on the basis of all stomach samples examined. These four single-species (or single-genus) items together comprised 59.6% of the total volume.

(2) Buckbrush was the leading item in the winter stomachs on the basis of percentage of volume, with jack pine, sunflower, and wild rose following in that order. Stomach samples composed of 90% to 100% buckbrush were not uncommon. In December 1945, when most of the winter stomach samples were secured, buckbrush and rose were carrying apparently good fruit crops.

(3) Autumn stomachs yielded major percentages of wild rose and red-root, relatively small amounts of buckbrush, and only traces of jack pine and sunflower.

(4) Samples collected in spring showed minor amounts of tree, shrub, and forb materials. Grasses and sedges (lumped in one category for the purposes of this study) occurred in every spring sample and comprised the major portion (33.7%) of the total volume.

The relatively high palatability of buckbrush, especially as winter food, the importance of wild rose in autumn and early winter, the probable role of fruit production in determining palatability in these two genera, the apparent liking for evergreen foliage during the winter months, and the shift to grazing during the spring, indicated here, have been pointed out (Hill, 1946) for white-tailed deer in the Black Hills, an area 200 airline miles northwest of Nebraska National Forest.

POST-HUNT STUDIES

Field observations made during the first three months of 1946. During the period of investigations prior to the deer hunt it was apparent to several observers that much over-browsing had occurred in various parts of the National Forest. However, no systematic attempt had been made to inventory the available food supply and record the condition of the range. The objectives of the investigations following the hunt were, therefore, to obtain information on (1) the number of deer on the area, (2) the condition of the range, (3) the feeding habits of the deer, and (4) any other phase of deer activity that might be useful in deer management.

The number of deer on the area. During the three months following the December deer hunt 122 deer were seen in 822 miles of travel. This amounts to more than twice as much traveling (822 compared to 370 miles) as was done in a comparable period before the hunt. Slightly more than one-third as many deer were seen after the hunt as were seen before (122 compared to 313). Eighty-two deer (67%) were seen in heavy timber. Twenty-three (19%) were in open timber. Seventeen deer (14%) were in grassland areas.

Condition of the range. Common observation and sample counts indicated that, in general, the available browse species most palatable to the deer in the heavy timbered areas had suffered severe hedging and high-lining during past years (Pl.7 and 8).This was also true

with respect to the browsing on 1945 shoot growth. On those areas heavily grazed by cattle there has been, apparently, a general decline in the amount of available browse.

In the areas of open forest, considerable evidence of browsing was noticeable, but, in general, it had not been as severe as that in the densely forested areas. Better stands and condition of plants were characteristic of the range here. In the open grasslands the available browse plants had been utilized somewhat, but there was little evidence of generally heavy browsing; entire thickets of excellent shrub growth were common without apparent signs of much old or recent browsing.

The feeding habits of the deer. Field observations and analyses of deer-stomach contents (Table 19) have shown that deer on the Nebraska National Forest feed on the buds, twigs, fruits, leaves, and stems of many species of plants. Among the tree species Austrian pine, jack pine, red cedar, and cottonwood seem to be of more value as deer food than willow, ash, black locust, hackberry, and others occasionally utilized. Among the shrubby species used are redroot, wild rose, poison ivy, buckbrush, and lead plant. Grasses and forbs are taken, grasses apparently being of marked importance during the spring.

The 1945–46 winter, having been for the most part mild with relatively little snow in late winter when the food supply usually becomes critical, was easy on the deer in that browse was readily available most of the time.

Observations made while following fresh deer tracks shortly after a snow storm in a few inches of snow, showed that ragweed, poison ivy, buckbrush, sunflower, choke cherry, wild plum and lead plant had provided part of the menu for at least two deer. Austrian and Scotch pine plantations showed evidence of past "highlining" (Plates 6, 7 and 8), probably during a winter when deep snow covered the shorter browse plants. Deer were seen feeding on the needles of Austrian pine in late March. As the warm weather of late March favored bud development, the deer varied their bill of fare with willow twigs and buds.

It is evident that the deer move into the heavy timbered areas, even though the winter is mild, and that they do not venture far away from cover. Following snowstorms the animals resume their browsing on the lower-growing plants if they are not snowed under. If the plants are covered for a great length of time, the deer take what they can reach of the available buds and twigs of larger trees. The extent of browsing and the consequent severity of "highlining" of trees has been somewhat dependent upon the depth and duration of the deep snow. Smaller trees and shrubs are hedged to the extent that they are available when snow is not deep, or to the extent that the tips are exposed above the snow.

Browse plot studies. In selecting plant species to be studied as indicators of range utilization by deer, buckbrush was designated as the major key species because it was found to be plentiful, well distributed over the range, highly palatable, and of marked importance in the animals' diet. Wild plum, choke cherry, and willow were included in the inventory, not because they met all the requirements of a good indicator species,

but because they showed indications of previous use by deer. Red cedar and Austrian pine areas were chosen because of evidence of previous use, availability, and relatively high palatability.

Twelve browse study plots were established; they are considered as fairly representative of browse conditions in the three general cover types on the forest reserve, i. e., dense timber, open timber, and grassland. The following accounts of the browse plots, prepared in March 1946, are included here in an effort to present a somewhat detailed picture of the nature of deer range in this unique area—a rapidly expanding, man-made, coniferous forest within a vast sandhill region where the high percentage of available water in the sandy soil "favors a postclimax of tall grasses" (Weaver and Clements, 1938).

Plot No. 1. Area about 225 square yards. Wild plum dominates with Virginia creeper overtopping about 16 square yards of the thicket. Buckbrush occupies the west end of the thicket and extends out to the south and north sides. A few plum whips are to be seen at the edge of the thicket. Good-sized jack pine occupy the area north of the thicket, while ponderosa pine are on the south side.

The larger plum trees have been high-lined and the few small ones are severely hedged. The thicket is badly beaten and broken, apparently by trampling and antler-rubbing. Deer may not have been responsible for all the trampling. No fresh or recent browsing is noticeable on the plums. The Virginia creeper vines seem now to be above the reach of the deer.

The buckbrush has been thoroughly hedged in the past. Sample counts on the 1945 seasonal growth indicate that about eighty per cent of the available browse was utilized. None of this appears to have taken place since the deer hunt of December 1945.

New growth is not now developed enough to give much indication of the 1946 potential growth. However, the amount of productive wood and buds appears to be small at present.

Plot No. 2. North slope. Buckbrush makes up most of the area (about 1300 square yards) with a few choke cherries, junipers, and wild roses present. All species except the juniper show heavy old browsing. As a whole, the thicket is quite heavily beaten down and thinned. The plants show much hedging.

The junipers, averaging about one and one-half feet in height have been lightly browsed recently. The sample counts indicate that the buckbrush was utilized about 16 per cent during the past summer or fall. No fresh browsing was noted. Live stems and buds seem to be twice as plentiful as those on comparable plants in Plot No. 1.

Plot No. 3. North slope. This area, of about 1800 square yards, is a long, narrow, thin thicket made up mostly of buckbrush with small amounts of poison ivy, choke cherry, and willow. All the shrub species present showed indication of heavy browsing in the past. The buckbrush shows the most hedging, the poison ivy least.

Sample counts on the buckbrush showed forty per cent of the 1945 growth browsed, probably all before the deer hunt last December. Fresh browsing (70%) was noted on the few willows present, which were producing new buds.

This area appears to be potentially better than Plot No. 2. However, shading may be a factor limiting the future value of this area for deer browse in a few years.

Plot No. 4. A strip planting of *Juniperus virginiana* about an acre in size. The trees vary in size from one and one-half to four and one-half feet high. A few shrubby species are to be found in limited quantities. Past heavy browsing and antler-rubbing are evident.

Sample counts on a 20 x 45 step (900 sq. yd.) area indicate that the 1945 growth was about 14 per cent browsed, none of it being fresh browsing. Except for the relatively few trees that have been badly

hedged and deformed by antler-rubbing, there are plenty of productive buds developing for the 1946 growth.

Plot No. 5. Steep north slope. An area of about 1200 square yards is made up of a thin thicket of buckbrush occupying a shallow pocket and extending up the north slope to meet three small clumps of pines on the uphill side. A grassy slope forms the north side of the pocket between the thicket and ponderosa pine to the northward. A few choke cherries, roses and willows are present.

Extensive old browsing is evident but the hedging effect is less noticeable than in Plot No. 2. Sample counts show that the buckbrush was about twenty per cent browsed before the deer hunt. A small amount of fresh browsing was noted on one sample. New willow buds in four samples were about fifty per cent browsed.

Plot No. 6. In open grassland. A circular belt of buckbrush averaging five steps wide occupies about 1400 square yards of a shallow pocket. To the south, up the north slope, is a belt of willows occupying about 2000 square yards of area. The east end of the belt joins a small thicket of choke cherry which is bisected by a fence. Both the buckbrush and the willow thickets are in the road area and unpastured.

The buckbrush is made up of a good stand of shrubs, untrampled and only lightly browsed in the past. Counts showed that browsing on the 1945 growth amounted to about six per cent. No fresh browsing was noticeable. There was no indication of fresh or recent browsing on the willow thicket which is now budding out plentifully. The choke cherry thicket showed indications of having been heavily hedged in past years, and had been severely trampled on the pasture side of the fence. However, no recent or fresh browsing was noted.

The buckbrush and willow components of this area are in very good growth condition. Very little hedging is noticeable. A high proportion of the 1945 growth is in good condition for production this season. The choke cherry thicket is not in such good condition.

Plot No. 7. On a north slope below a ponderosa pine plantation. An area of about 500 square yards on the slope is covered by the rather thin stand of small choke cherry trees. Hedging in past years has been severe. The 1945 growth was apparently not good. Sample counts show that from the available supply of shoots eight per cent were browsed previous to the 1945 deer hunt. There is no noticeable evidence of fresh browsing.

A good supply of swelling buds is to be seen on both the old and the new wood.

Plot No. 8. A thicket of choke cherry trees two to three feet high covering an area of about 225 square yards.

Very little evidence of old browsing, and no hedging was to be seen. No recent or fresh browsing was noted. This thicket made good shoot growth (average of six inches per stem) in 1945. A good supply of buds is now available for further growth. It appears to be a relatively new thicket that may increase greatly under favorable environmental conditions.

Plot No. 9. This is an area of large Austrian pine trees that show evidence of considerable highlining in past years. A few small trees have been severely hedged. Jack pine plantations are on the east, west, and south sides of this area.

All of the browsing effect noted was old except for that on two trees. A deer was seen at three different times browsing on a low-hanging branch near the road. It is estimated that not more than four per cent of the available supply of browse is now being utilized.

Plot No. 10. A choke cherry thicket that occupies an area of about 2800 square yards, surrounding a group of two large and ten small hackberry trees (Pl. 6C). A fence divides the area about evenly into a west (road) half and an east (pasture) half. A few rose and buckbrush shrubs are to be found in open parts of the thicket and along the edges. A few wild plum trees are along the fence. The choke cherry trees average eight feet tall and

one and one-half inches in diameter. The south half of the thicket is topped by a heavy mat of wild grape vines.

East of the choke cherry thicket, down a draw where it widens out, is an area of about 2500 square yards of buckbrush, a very good stand of plants. To the south of the whole area, on a north slope, is a plantation of ponderosa pine, the trees averaging six feet in height.

The choke cherry thicket shows evidence of highlining on the larger plants and hedging on the smaller plants along the edge. Much antler-rubbing and trampling has occurred. The grapes have been browsed in the past. Utilization of the choke cherry was apparently heavy on both sides of the fence. Very little evidence of recent browsing was found on the pasture side, but sample counts on the road side indicated that about six per cent of the available shoots had been browsed in the past season.

Sample counts in the buckbrush thicket showed that about forty-four per cent of the available shoots had been utilized during the past season. No fresh browsing was noted.

The small hackberry trees had been lightly browsed in 1945.

Plot No. 11. A plantation of small red cedar trees averaging not more than two feet in height. Beyond them is a 16-acre plantation of older trees averaging about eight feet in height.

Some evidence of old browsing and antler-rubbing is to be seen in both parts of the area. Sample counts in the older plantation showed less than one per cent browsing and no evidence of fresh browsing. In the area of smaller trees near the road, counts showed that the browsing on 1945 growth amounted to 15 per cent on the pasture side of the fence and nine per cent on the road side.

The older trees are large enough to be beyond the danger of hedging by deer, but might possibly be highlined in the future. The small trees are at the stage where hedging has started on many of them. Good seasonal growth the past season makes a plentiful supply of new shoots available for future growth this year.

Plot No. 12. A plum thicket in a pocket. A plantation of eight-foot pine trees occupies the hill to the south. The plum thicket covers an area of about 100 square yards next to the road. The trees average seven feet tall. A buckbrush thicket covers an area of about 3000 square yards, about one-fourth being in the road area and set off from the other (pasture) three-fourths by a fence. It is a denser stand of shrubs than any similar thicket so far encountered in the Forest area. A few rose, willows, and small cedars are present.

Very little old browsing signs were noticeable and no recent or fresh signs were to be seen in the plum thicket.

The buckbrush thicket shows some evidence of old browsing and has been somewhat beaten down, more on the pasture side than on the road side, but no hedging was noted. Sample counts indicate 57 per cent browsing on the pasture side and 22 per cent on the road side during the past season. The willows, roses, and cedars appear to be unbrowsed. This is the best of all the plots as far as growth and stand of plants are concerned.

During the year following the establishment of the browse study plots in the Bessey Division of Nebraska National Forest, monthly inspections were made, through March 1947. Quarterly inspections have been made since. In conjunction with these periodic inspections, general observations outside the plots have also been made.

Two mild winters with little snow followed the herd reduction in December 1945. Shrubs and forbs were consequently readily available to deer. Examination of the browse plots indicated that, although use by deer was generally light compared to that preceding the hunt, winter movements of deer into the more heavily wooded areas were accompanied by relatively heavy

browsing, particularly on buckbrush and juniper. The presence or absence of a fruit crop on the buckbrush apparently determined whether or not deer utilized this species in late fall and winter.

Indications of very light browsing were found during early spring on buckbrush and choke cherry buds and twigs. The small stands of sandhills willow were heavily browsed at this time.

Very light occasional browsing was noted during the summer months on choke cherry, juniper, poison ivy, willow, wild rose, sand cherry, lead plant, and sunflower. Redroot was found to be more heavily browsed and probably constitutes the most important shrub for summer use.

In early September, after a rain, tracks of two deer led to fresh browse sign on annual sunflower, *Helianthus annuus* L., two species of goosefoot, *Chenopodium* sp., and compass plant, *Silphium lacinatum*. These plants were dry, having been recently mowed along the graveled trail. Nearby wild rose, choke cherry, sand cherry, and lead plant were untouched. This observation, together with several others of browse sign on frost-killed sunflowers, indicates that forbs comprise a substantial part of the deer's diet in this area in the fall.

The shrubs and trees so lightly browsed during the summer months, including buckbrush, received increasing attention from the deer as cold weather approached. Heavier browsing on juniper was accompanied by antler-rubbing which injured many small trees during October and November, causing their deformation. Ponderosa pines, choke cherry, and hackberry trees were occasionally found to be antler-rubbed.

Buckbrush and juniper were the important browse species during the winter months, although, under the conditions of the winter of 1946–47 and 1947–48, jack pine, soap weed, willow, rose, and Austrian pine were utilized lightly, apparently by choice rather than by necessity.

Fall and winter browsing of buckbrush occurred heavily on the shoots that came up from the roots during the previous growing season. Thickets with little or no such growth—and there were several such thickets noted—were found to have been used little or not at all. Fruits and twigs on the old plants were relatively unused.

Condition of the Range—Fall of 1948. During the three growing seasons following the December 1945 deer harvest by hunters, consistent improvement in browse conditions was notable in the National Forest area. Herd reduction, followed by favorably mild winters, had resulted in generally lighter utilization of browse species by the deer. However, some of the juniper plantations still showed heavy browsing and antler-rubbing by deer. Poor fruit crops on browse species during the 1948 growing season detracted somewhat from the otherwise generally good condition of the range at that time.

RECOMMENDATIONS

In the light of information gathered in deer herd and range investigations and reported here, it is recommended (1) that management of deer in Nebraska National Forest and elsewhere in the state be aimed at keeping the herds within the biological limits (carrying capacity) of the range, (2) that herd

reduction measures be applied before marked deterioration of the range has set in due to over-use by deer, and (3) that deer removals be effected through hunter participation in accordance with the cropping principle. It must be added that satisfactory management of deer in Nebraska cannot be categorically expected in all areas under the limitations of the "buck law" which has been in effect since 1947.

SUMMARY

Native Rocky Mountain mule deer, *Odocoileus hemionus hemionus* Rafinesque, have naturally restocked most, if not all of Nebraska's deer range during the last twenty years. In the Bessey Division of Nebraska National Forest evidences of an over-population of deer became apparent in the late 1930's.

This National Forest Reserve is an area of 90,388 acres in north-central Nebraska near the southeastern border of the vast sandhill region. Grasses dominate the native vegetation of the area, as throughout all of the sandhill region, with native shrubs occurring more or less abundantly. A continuous planting program, begun in 1903, has covered about 24,000 acres with growing conifers, principally jack pine, ponderosa pine, and eastern red cedar.

All information gathered relative to deer on the Forest from 1941 through 1944 indicated that the available deer range there was overstocked. Intensive investigations conducted in the autumn of 1944 revealed the need for removal of not less than 300 deer in the immediate future. In 1945 the Nebraska Legislature authorized deer hunting on the Bessey Division; the Game Commission scheduled a supervised hunt under special permit system for December 1–21, inclusive, 1945.

Pre-hunt studies, conducted during September, October, and November, 1945, furnished data indicating (1) an adult sex ratio of one buck to two does, (2) a ratio of one adult buck to five of all other deer seen, (3) an old-young ratio of about 2:1, (4) a ratio of 71 fawns per 100 does, (5) a tendency for the deer to move into heavier timber as winter approached, and (6) the onset of breeding in October.

In keeping with the decision to attempt the harvest of between 300 and 400 deer on the Forest, 500 deer hunting permits were issued. Applications for permits were received from 998 persons; the 500 permittees were selected at public drawing; 448 permittees actually hunted.

A sighting-in range near the hunting camp (Forest Headquarters) was popular with the sportsmen and is thought to have contributed to hunting success.

Seventy-eight per cent of those hunting took deer. Successful hunters came from 76 of Nebraska's 93 counties.

A total of 361 deer were killed; 248 were taken in the first week of the season, 89 in the second week, 24 in the third week.

Successful hunters used from 1 to 6 days for their hunting; they averaged over four hours of total hunting time, and 3.2 hours of hunting on the day of the kill.

More bucks were killed in the first two hours of the hunting day than in any other two-hour period; the doe kill was highest in the late afternoon.

The area open allowed over 450 acres per hunter on opening day, 1000 acres

per hunter on the second day, and 1250 acres or more on other days.

The take in the area open to hunting averaged about 2.6 deer per section.

Considering the takes within the four cover types on the Forest area, namely, grassland, brush, open timber, and heavy timber, the greatest percentage (45) of deer was taken in the open timber.

Most of the deer taken (62%) were standing when shot. Other hunting data, such as number of deer and number of other hunters seen by individual hunters while hunting, guns used, length of shots, etc., are given.

All of the deer taken (361) were, so far as is known, brought to a checking station.

One hundred and fifty-four males and 207 females were checked, including 30 male fawns and 31 female fawns. Sex and age classifications are shown.

Average weights of does changed little after passing the 2½-year-old class; average weights of bucks increased rather evenly up to the 7½-year-old class.

Antler measurements show considerable increases in successive age classes up to the fourth year, smaller increases during the next three years, and small changes after that.

Antler points on males 3½ years old, or older, varied in number from 2x2 to 5x7; 4x4 points were the most common.

Average lengths of hind feet were higher for bucks than for does in all age classes, including fawns.

Swollen necks were noted in none of the buck fawns, in 60 per cent of the yearlings, 89 per cent of the 2½-year-olds, and 95 per cent of those 3½ years old or older.

All yearling does were dry; 41 per cent of the does 2½ years old or older were wet.

About two-thirds of the deer were classified as in good condition; few fat deer were taken.

Four ear-tagged deer were bagged; at least 29 were ear-tagged in the area in the two years preceding the hunt.

Two white-tailed does were taken; freshly shed antlers from a white-tailed buck were found on December 14.

Examination of many carcasses and the viscera and nasopharyngeal cavities of several deer revealed an apparently low incidence of parasites. Relatively few specimens of the following were found: The cestodes *Moniezia benedeni* (Moniez, 1879) and *Thysanosoma actinoides* Diesing, the nematode *Setaria cervi* (Rudolphi, 1819), larvae of the cuterebrid fly *Cephenomyia pratti* Hunter, and the mallophagan louse *Trichodectes* sp.

Analysis of stomach samples from 78 mule deer secured on or in the immediate vicinity of the Forest from November 1943 to March 1947 indicate (1) the marked importance of buckbrush, jack pine, wild rose, and sunflower in the diet of deer in this situation, (2) buckbrush as the leading item in the winter stomachs, (3) the apparent liking for the foliage of conifers during the winter, and (4) a brief shift to grazing in the spring.

Post-hunt studies on deer within the Forest Reserve during the three months following the hunt revealed (1) fewer deer, with the greatest percentage (67) being seen in heavy timber, (2) severe hedging and high-lining during recent years in the more heavily timbered areas, (3) less severe browsing

in the open forest, and (4) little evidence of general heavy browsing in the open grasslands where entire thickets of excellent shrub growth were common without apparent signs of much old or recent browsing.

Intensive browse studies were undertaken on 12 plots; somewhat detailed descriptions of the plots are given. These studies have shown that, (1) although use by deer was generally light compared to that preceding the hunt, winter movements of deer into the more heavily wooded areas are accompanied by relatively heavy browsing, particularly of buckbrush and juniper, (2) the small stands of sandhill willow have been heavily browsed during early spring, (3) redroot probably constitutes the most important shrub for summer use, and (4) fall and winter browsing on buckbrush occurred almost exclusively on shoots of the year.

It appears that herd reduction on the Bessey Division of Nebraska National Forest, followed by favorable mild winters, has resulted in generally lighter utilization of browse species by deer. Some of the juniper plantations continue, however, to show heavy use both as browse and for antler-rubbing.

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Accepted for publication Aug. 19, 1950.

SOME FACTORS AFFECTING THE GROWTH AND SURVIVAL OF MULTIFLORA ROSE AS COVER FOR QUAIL IN DAVIS COUNTY, IOWA[1]

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Studies have been in progress for several years on the management of bob-white quail (*Colinus v. virginianus L.*) on a 620-acre state-owned public shooting tract near Eldon, in Davis County, Iowa. This area is typical of the hill land of south central Iowa. Adequate cover is important in quail management. Multiflora rose (*Rosa multiflora thunbergiana* Thory) is one of the plants that has possibilities in helping meet these needs. Eldon, Iowa is in the Temperate Zone 4, about 90 miles north of the northern most boundary of Zone 5, in which this rose is most hardy. (Rehder, Manual of cultivated trees and shrubs hardy in North America. MacMillan Co., N. Y., 1947). Plantings were made at the Davis County tract in the spring of 1946 to determine if multiflora rose was adapted to the climatic conditions of that area and also to study some of the soils and cultural practices best adapted to growing this plant. The plantings were made on different soil types, depth of topsoil, and with different cultural and fertility practices.

[1]Journal Paper No. J-1811, Project No. 494, Iowa Agricultural Experiment Station, Ames, Iowa. U. S. Fish and Wildlife Service, Iowa State College, Iowa State Conservation Commission, and Wildlife Management Institute Cooperating.

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The rose seedlings were received late in April, 1946, from the U. S. Soil Conservation Nursery, Elsberry, Missouri. Approximately 85 percent of the 11,500 plants were two years old and the rest were one year old. Rains repeatedly interrupted the planting schedule, but nearly all of the plants were in the ground by the middle of June.

In 1947 an excess of precipitation in June and a severe drought in July and August were unfavorable for the growth of the rose seedlings. In 1948 weather conditions were beneficial, except for a short drought during August.

Twelve of the planting sites were selected for analysis (Table 1) of the response of the rose to depth of topsoil, soil moisture, plant competition, shade tolerance, planting techniques, and insect damage. In the falls of 1947 and 1948, the percentage of stand per site was determined on the basis of presence or absence of every fifth rose plant; in 1948, the height of every fifth one was measured from the ground to the tip of the longest branch. Count-list quadrats were used in measuring plant competition. In August of the second growing season, the plants of 10 quadrats (1/10,000-acre each) were counted at each site and their mean heights and the amounts of bare ground in the quadrats recorded.

TABLE 1.—A SUMMARY OF THE MULTIFLORA ROSE DATA FROM TWELVE PLANTINGS LOCATED IN DAVIS COUNTY, IOWA, 1946–1948

Planting	Planting Procedure: At Planting	Planting Procedure: After Planting	Soils: Type	Soils: Treatment	Stand Percent: 1947	Stand Percent: 1948	Plant Competition: When Planted	Height** of rose in in. 1948: end of growing season	Remarks
A Watershed above new pond. 983 plants. 2-yr. old.	Seedbed. Single row. April 19, 1946.	Seeded *Lespedeza stipulacea* Maxim. Untended.	Weller 6–8"*	Lime	99	99	None.	36	Vigorous plants. Insect damage.
B Back base of new ponds. 372 plants. 2-yr. old.	No seedbed. Double row. April 19, 1946.	Untended.	Lindley subsoil	Lime and Fertilizer	97	90	*Secale cereale* L. *Phleum pratense* L. *Agrostis alba L.*	49	Vigorous plants. Soil moisture supplemented by seepages.
C Back shoulders of new pond fill. 368 plants. 2-yr. old.	No seedbed. Double row. June 2, 1946.	Untended.	Lindley subsoil	Lime	80	75	*Secale cereale* L. *Phleum pratense* L.	25	Stunted plants.
D Newly constructed diversions. 1916 plants. 2-yr. old.	No seedbed. Double row. April 10, 1946.	Untended.	Lindley subsoil	Lime and Fertilizer	82	12	*Secale cereale* L. *Phleum pratense* L. *Agrostis alba L.*	25	Stunted plants. Insect damage.
E Across fill of five-year old pond. 553 plants. 2-yr. old.	Seedbed. Single row. June 4, 1946.	Untended.	Lindley 0–2"	Lime	100	99	*Poa compressa* L. *Lespedeza stipulacea* Maxim.	68	Shaded site. Soil moisture supplemented by pond. Vigorous plants.
F Watershed above old pond. 487 plants. 2-yr. old.	No seedbed. Single row. April 25, 1946.	Seeded *Lespedeza stipulacea* Maxim. Untended.	Weller 0–2"	Lime	96	91	None.	30	Stunted plants. Insect damage.
G Border between garden and barn lot. 1360 plants. 1-yr. old.	Seedbed. Single row. July 3, 1946.	Cultivated.	Lindley over 8"	Barnyard Manure	100	100	None.	64	Vigorous plants.
H Permanent vegetation above new pond. 1414 plants. 2-yr. old.	Cut out sod. Single row. April 12, 1946.	Untended.	Lindley 6–8"	Lime	60	0.0	*Phleum pratense* L. *Lespedeza stipulacea* Maxim. *Aristida dichotoma* Michx.	100% loss	Complete failure.
I Newly seeded and mulched watershed. 1091 plants. 2-yr. old.	No seedbed. Double row. April 27, 1946.	Untended.	Lindley 2–4"	Lime	46	0.1	*Trifolium pratense* L. *Phleum pratense* L. *Agrostis alba* L.	20	Only two plants survived.
J In fence row along road. 1291 plants. 2-yr. old.	Seedbed. Single row. April 9, 1946.	Untended.	Lindley 2–4"	None.	89	52	*Aristida dichotoma* Michx. *Poa pratensis* L. *Ambrosia artemisiifolia* L.	30	Stunted plants. Insect damage.
K Around gullies in pasture. 1415 plants. 2-yr. old.	Seedbed. Single row. June 15, 1946.	Untended.	Lindley subsoil 2–4"	Lime	87	63	None.	25	Stunted plants. Insect damage.
L Across fill of five-year old pond. 365 plants. 1-yr. old.	No seedbed. Single row. June 10, 1946.	Untended.	Lindley subsoil	None.	99	96	*Lespedeza stipulacea* Maxim. *Aristida dichotoma* Michx.	13	Stunted plants.

* Depth of topsoil.
** Mean height of each site.
*** Lime at rate of 3 tons per acre and Fertilizer at rate of 300 #/A 3–12–3.

In Table 1, it may be seen that the responses of the rose at sites A, F, G, and K had evident relation to the depth of the topsoil (A horizon). Topsoil six or more inches deep seemed to grow the tallest rose plants, providing that the factors of soil moisture and plant competition were comparable. The soil treatments mentioned in the table (three tons of lime and 300 pounds of 3–12–3 fertilizer per acre) were primarily intended to improve growth conditions for grass and legume seedings on pond constructions and for pasture renovations.

The best comparative data on effects of soil moisture on rose growth are those of sites B, C, E, and L. Plantings having a source of moisture other than rainfall had an advantage. At sites E and G, the preparation of a seedbed and cultivation were not judged to be as important as available soil moisture.

Success or failure of plantings at sites D, G, H, I, and J showed an apparent relation to plant competition. Sites G and H, where soil types and fertility were comparable, reflect extreme conditions. At site G, the plants were set in a prepared seedbed and cultivated, whereas in H they were set in spots from which sod had been removed and not cultivated thereafter; the G plantings thrived and the H plantings failed. Plantings at sites D, I, and J showed not only the influence of competing vegetation but also that multiflora rose might be less capable of competing with certain domesticated grasses and legumes than with common weeds. However, Korean lespedeza seeded on the seedbed in infertile soils seemingly favored good growth of the rose.

At site E, the rose plantings grew vigorously in the shade. These were on top of a pond fill near the water line and at least 12 feet above the ground level where the adjacent trees grew. Possibly, the frequently observed retarding effect of bordering trees may be attributed to competition for moisture rather than for sunlight. A planting in well-watered, fertile soil at the north side of a home in Eldon made nearly 40 inches growth in one season though shaded the entire day.

During the summer of 1948, several plantings were damaged by grasshoppers, chiefly at sites where plant competition was severe. The grasshoppers seemed to prefer the multiflora rose. At most sites, only leaves were eaten, but at D and J all of the bark was eaten from entire rose plants. Other insect damage was of little significance.

SUMMARY

Topsoil six or more inches deep seemed to grow the tallest rose plants, providing the factors of soil moisture and plant competition were comparable. The importance of soil moisture was more prominent in planting sites with topsoils less than six inches deep. An increase in plant competition resulted in a decrease in rose stand percent. When there was not any competition for soil moisture, shading by trees did not appear to have any adverse effects on the growth of multiflora rose.

Accepted for publication June 12, 1950.

WOOD MOUSE AND BOX TURTLE POPULATIONS IN AN AREA TREATED ANNUALLY WITH DDT FOR FIVE YEARS

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On June 5, 1945, a 117-acre tract of bottomland forest on the Patuxent Research Refuge was treated with an aerial application of DDT in oil at 2 pounds per acre. DDT reached ground level in a much smaller amount (thousandths to hundredths of a pound per acre) because of the heavy tree canopy and wind drift. Treatment was repeated annually through 1949 for a total of 5 applications. DDT was applied at the rate of 2 pounds per acre each year except 1946, when the rate was 1.1 pounds per acre. Dates of treatment were June 8, 1946; May 21, 1947; June 3, 1948; and June 1, 1949.

Field studies of wood mice and box turtles were made in 1945 and in 1949 as part of the program to evaluate the effects of DDT on vertebrate animals. The immediate effects on the wood mouse population following spraying in the first year have been reported (Stickel 1946).

Wood Mice

Wood mouse (*Peromyscus leucopus noveboracensis*) studies in 1949 followed the same plan used in 1945. Trapping was done on a ten-acre plot in the DDT treated area and in a ten-acre plot in bottomland forest 1-1/8 miles distant. Trap positions had been marked in 1945 by numbered wooden stakes. Traps were placed in the same locations in 1949. Five rows of five traps each were arranged on a 165-foot grid. Large size (9x9x3 inch) Sherman metal traps were used. In 1949 whole shelled corn was added to each trap in addition to the rolled oats and peanut butter bait, and no nesting material was put in the traps. These changes may have been responsible for the fact that there was only one trap fatality in 1949, while the 1945 losses were heavy (Llewellyn 1950). In 1949 the mice were marked with numbered metal ear tags, a great saving in time over the ear-punch, toe-clip system used in 1945.

In 1949 there were two trapping periods in each area, one before and one after the DDT treatment. The first trapping was from May 14 through May 18. DDT was applied June 1, and the second trapping was from June 10 through June 14.

Results in 1949.—The number of different individuals taken were as follows:

	DDT-treated area	Check area
Before spraying	41 (21♂, 20♀)	32 (18♂, 14♀)
After spraying	45 (28♂, 17♀)	39 (27♂, 12♀)

There appears to be no significant difference in mouse numbers in DDT and check areas before and after DDT treatment. Chi square tests show no statistically significant difference.

The number of animals marked in Period I (before spraying) and retaken

in Period II (following spraying) were as follows:

	DDT-treated area	Check area
Marked animals released in Per. I (May 14–18, 1949)	40 (20♂, 20♀)	32 (18♂, 14♀)
Marked animals retaken in Per. II (June 10–14, 1949)	28 (15♂, 13♀)	17 (12♂, 5♀)

These data also show no statistically significant difference between DDT-treated and check areas.

Comparison of 1945 with 1949.—The number of wood mice taken in the trapping periods in 1945 and 1949 were as follows:

	DDT-treated area	Check area
1945 (May 3–7)	40	27
1949 (May 14–18)	41	32
1949 (June 10–14)	45	39

Results in the two areas show no statistically significant difference over the five-year period.

BOX TURTLES

A thirty-acre plot in the center of the DDT-treated area was selected for study of box turtles. (*Terrapene c. carolina*). A similar thirty-acre plot in bottomland forest 2 miles distant was used as a check. Turtles were found by searching on warm days. In 1945 Robert T. Mitchell and Clyde Vance helped with the collecting. Most collections in that year were made in April and May, with a few in late March and early June. Collecting effort was distributed over the plots as uniformly as feasible, although some parts certainly received more attention than others. Location markers at 165-foot intervals, or closer in some places, helped insure coverage of the area and were useful in recording locality data. The 1949 collections were made in June and July. The sites of first capture of turtles collected in 1945 were plotted on a map, and used as a guide in the 1949 collecting. Different sections of the plot were visited on different days, since only one person was collecting and the entire area could not be covered in one trip. In both years the turtles were marked by filing notches in the marginal scutes according to a code system (Cagle 1939), so each individual could be recognized on recapture. Localities were recorded, turtles were measured in the field with vernier calipers, and released at the site of capture.

Results.—In 1945 a total of 73 adult turtles were collected in the DDT area and 74 in the check area during the spring census period. In 1949, following the fifth annual spraying, 86 were collected in the DDT area and 82 in the check area. In the treated area 28 of the turtles collected in 1949 were repeats from 1945. In the check area 29 of the 82 collected in 1949 were repeats from 1945 (Table 1). In neither year was the entire population collected, and numerous unmarked turtles remained in each area. Additional recoveries of 1945 turtles could almost certainly have been made with continued collecting in 1949; new recoveries from 1945 were made on every day of collection, including the final one.

Evaluation of possible DDT effects

TABLE 1.—BOX TURTLES COLLECTED IN DDT AND CHECK AREAS

DDT Area				Check Area			
1945 (Apr.-June)	1949 (June-July)			1945 (Apr.-June)	1949 (June-July)		
	Tot.	New	Repeats from 1945		Tot.	New	Repeats from 1945
♂ 38	48	32	16	♂ 33	42	27	15
♀ 35	38	26	12	♀ 41	40	26	14
Tot. *73*	*86*	58	*28*	Tot. *74*	*82*	53	*29*

can, however, be made by comparison of collections in the two areas, without the necessity of collecting every individual in the population. It is apparent that there is no essential difference in the results from the two areas. Statistical tests also show no significant difference.

In 1945 a few turtles that had not reached adult size were collected, but their numbers were too small for proportional comparison of the areas. Four were retaken in the DDT area in 1949, and remeasured. Growth in carapace length is shown in Figure 1. Comparison is made with the growth of a few other turtles that were collected over this period. These additional records were obtained from the check area, but the early collections were not made at the time of the regular census trips used in obtaining data on adults above. Growth in the DDT area turtles seems entirely normal, although the sample is small.

SUMMARY

A 117-acre area of dense woodland on the Patuxent Research Refuge received an aerial application of DDT in oil at the rate of 2 pounds per acre annually for five years. DDT reached ground level in a much smaller amount (thousandths to hundredths of a pound per acre). Treatment was made during the first week of June of each year from 1945 through 1949.

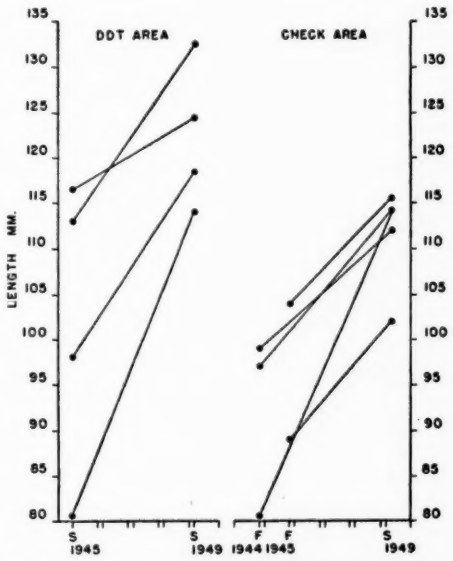

FIGURE 1.—Growth in millimeters carapace length of 4 box turtles from the DDT area and 5 turtles from the check area. S and F indicate spring and fall, seasons when the measurements were made.

Field studies of the wood mouse population in DDT and check areas showed no significant differences in the two areas before and after the 1949 DDT treatment. There was no significant difference between trapping sam-

ples taken in DDT and check areas in 1945 and those taken in 1949.

Field studies of the box turtles in DDT and check areas in 1945 and 1949 showed no significant difference in population size. Growth of the four young turtles taken in the DDT area in both 1945 and 1949 appeared to be normal in comparison with growth of check area turtles.

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Accepted for publication June 30, 1950.

OVERFLOW AND DISPERSAL OF MARTEN AND FISHER FROM WILDLIFE REFUGES

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It has been the opinion of wildlife administrators during the last few decades that there might be two ways of dealing with the problem of decreasing fisher and marten populations, namely a regulation of trapping pressure by the setting of trapping seasons and the establishment of wildlife refuges.

Up to the present time, the regulation of trapping pressure by seasons has failed. Seasons for fur-bearing animals have existed in Ontario at least since 1860, but even when they are properly enforced or regulated, their inefficiency is clearly demonstrated. The season for marten was closed in 1948 and for fisher, in most of Ontario, in 1949.

The establishment of wildlife refuges, in which trapping of fur-bearers is prohibited, has proven to be effective as long as these areas are properly protected by law enforcement personnel. For example, in Algonquin Provincial Park and in the Chapleau Game Preserve, fisher and marten were not only saved from extermination but increased considerably during the past two decades. Conversely, in Quetico Provincial Park where enforcement was inadequate they decreased in number because of poaching.

The value of wildlife refuges for the protection and increase of fur-bearers is well recognized in North America at the present time. The Hudson's Bay Company has established special refuges for the management of fur-bearers such as beaver and muskrat with satisfactory results and has recently started

*Appreciation is expressed to Vincent Crichton, Fish and Wildlife Specialist, Department of Lands and Forests, Chapleau, who compiled fur returns for the Chapleau Forest District, and Drs. C. H. D. Clarke and John T. Emlen for critically reading the manuscript. Mr. L. M. Morrison, Statistician with the Department of Lands and Forests, made a statistical analysis of data presented to him. The Hudson's Bay Company was kind enough to allow the author the use of some of their statistics.

marten refuges on the east coast of James Bay and on Akimiski Island. However, the author is not aware of the existence of a critical evaluation of the dynamics of the overflow of fur-bearers from refuges. The present study makes such an effort.

By using trappers' fur returns for the Chapleau Forest District over the seasons 1941–42 until 1949–50, maps were prepared, giving the distribution and abundance of the different fur-bearers per individual trap-line area. These were analysed for indications of a possible overflow of these species from Chapleau Game Preserve, which was instituted in 1925, into peripheral areas in the District. Using methods des-

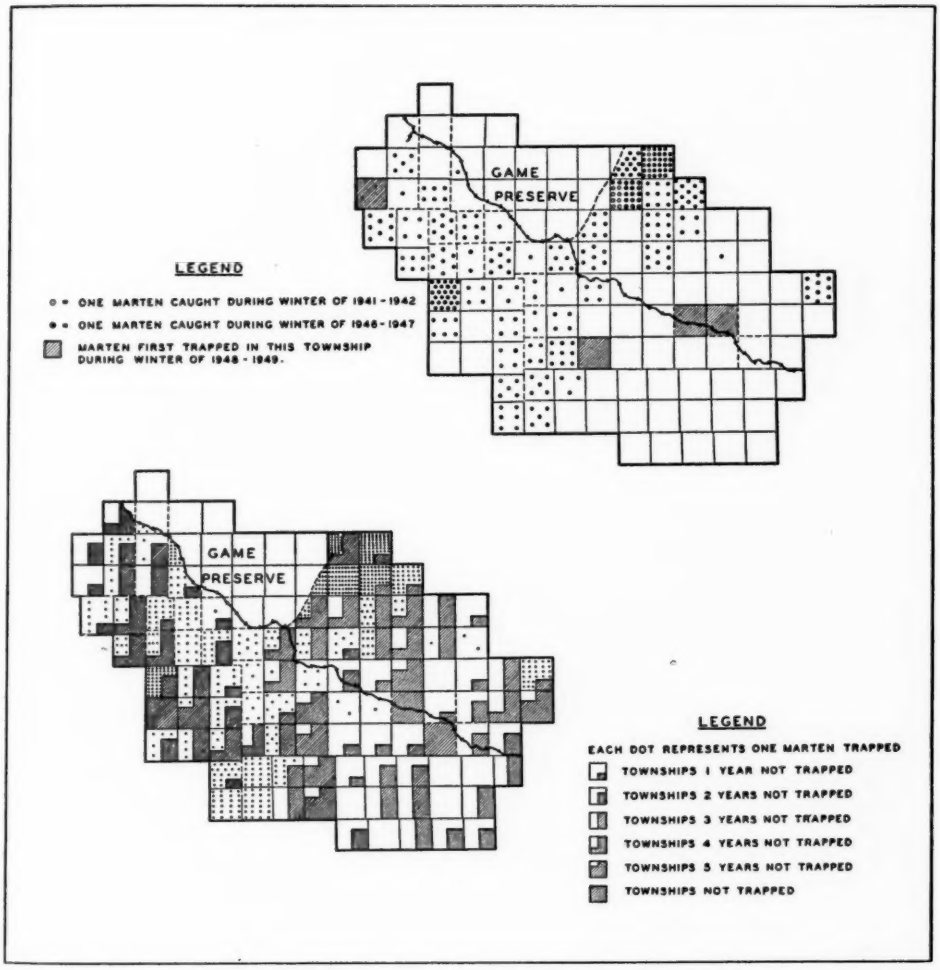

GAME
PRESERVE
LEGEND
ONE MARTEN CAUGHT DURING WINTER OF 1941-1942
ONE MARTEN CAUGHT DURING WINTER OF 1946-1947
MARTEN FIRST TRAPPED IN THIS TOWNSHIP DURING WINTER OF 1948-1949.
GAME
PRESERVE
LEGEND
EACH DOT REPRESENTS ONE MARTEN TRAPPED
TOWNSHIPS 1 YEAR NOT TRAPPED
TOWNSHIPS 2 YEARS NOT TRAPPED
TOWNSHIPS 3 YEARS NOT TRAPPED
TOWNSHIPS 4 YEARS NOT TRAPPED
TOWNSHIPS 5 YEARS NOT TRAPPED
TOWNSHIPS NOT TRAPPED

FIG. 1. The upper map shows the increase of marten in Chapleau Forest District, while the lower map shows the density, based on trappers' returns over the period 1941-'42 to 1946-'47. Townships 9H, 10H, 9G and 10G are situated in the southwest corner of the map.

cribed later it was found that in case of beaver, muskrat, mink, lynx and otter no definite influence of the Preserve could be shown. However for marten, and likely the fisher, an overflow picture can be established.

ANALYSIS OF MARTEN AND FISHER DATA

Using trappers' returns for the period 1941–42 to 1946–47, Peterson and Crichton (1949) write that if a line is drawn across Chapleau Forest District, dividing equally the trapping areas of the south eastern portion from the north western portion, it will be found that 84 per cent of the fisher and 98 per cent of the marten are taken in that half of the district nearest the Chapleau Game Preserve. That fisher and marten were abundant there as compared with

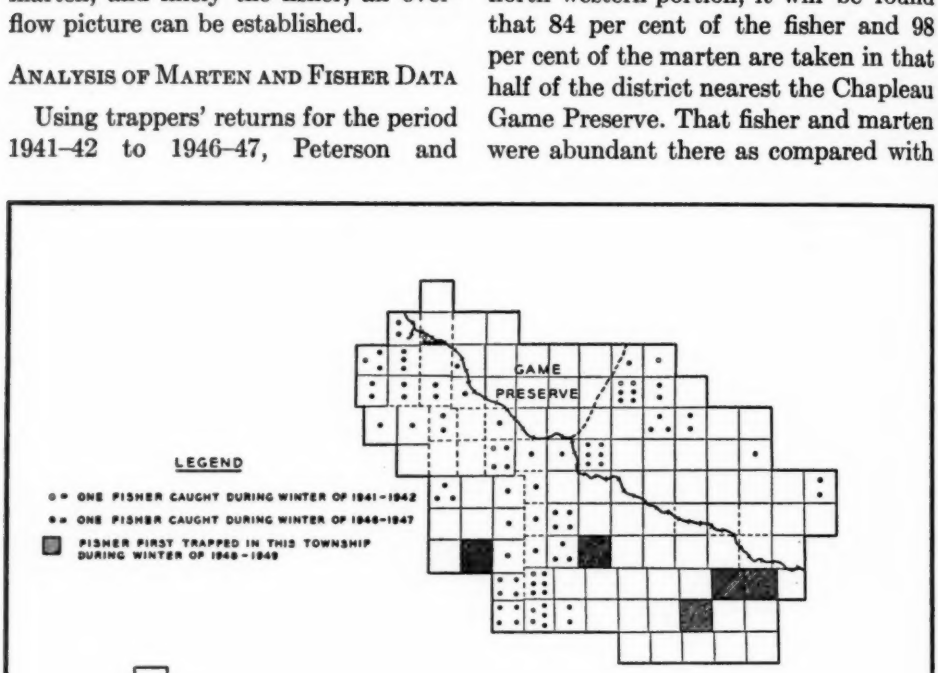

GAME PRESERVE
LEGEND
ONE FISHER CAUGHT DURING WINTER OF 1941-1942
ONE FISHER CAUGHT DURING WINTER OF 1946-1947
FISHER FIRST TRAPPED IN THIS TOWNSHIP DURING WINTER OF 1946-1949
GAME PRESERVE
LEGEND
EACH DOT REPRESENTS ONE FISHER TRAPPED
TOWNSHIPS 1 YEAR NOT TRAPPED
TOWNSHIPS 2 YEARS NOT TRAPPED
TOWNSHIPS 3 YEARS NOT TRAPPED
TOWNSHIPS 4 YEARS NOT TRAPPED
TOWNSHIPS 5 YEARS NOT TRAPPED
TOWNSHIPS NOT TRAPPED

FIG. 2. The upper map shows the increase of fisher in the District, while the lower one shows the population density, based on trappers' returns over the period 1941-'42 to 1946-'47.

surrounding areas in the 1930's can be ascertained from the success of two poachers who in an area of about 6 square miles in Mageau and Racine Townships took not less than 42 martens and 6 fishers during the period October 15th to December 15th, 1937, while in the Chapleau District practically no specimens of either species were caught.

Figures No. 1 and No. 2 were prepared to show the relative densities of these species in Chapleau Forest District based on trappers' returns for the period 1941–42 to 1946–47. Only the northern half of the District is shown on the maps. The density patterns show clearly that fisher and marten are more abundant close to the Game Preserve than away from it. Also shown are the distribution of fisher and marten in the seasons 1941–42 and 1946–47, and the outward spread in 1948–49. Apparently not only an increase, but also a range expansion in population must have taken place.

In order to obtain quantitative data on an overflow of fisher and marten from the Game Preserve into surrounding areas, a statistical analysis of the trappers' returns for each year of the period 1941–42 to 1946–47, was made. Variables in environment and in sampling procedures which might exert distorting influences were considered first and evaluated in so far as possible. Such variables included the reproduction of local populations around the Preserve, habitat influence, changes in market value of pelts, differences in trapping and poaching pressure between trap-lines and localities, influence of the war period, population cycles, weather conditions in different winters, and amount of selective trapping.

The influence of residual populations outside the Preserve on the increase of fisher and marten around it must be considered negligible in case of the marten. The latter species was practically absent from a region of about 25 miles in width around the Game Preserve between 1920 and 1930 and has reappeared and increased since that time. Figure No. 3, showing a reconstruction of the possible disappearance and reappearance of marten in the region around the Preserve indicates that the species was present in a restricted area around the Game Preserve in 1940 and spread from there in all directions. The map indicates 2 exceptions to this in the Chapleau District: marten were present in the 1920's in Benton, 9H, 10H, 9G and 10G townships, situated respectively about 45 miles southeast and 30 miles south of the Preserve. However, they

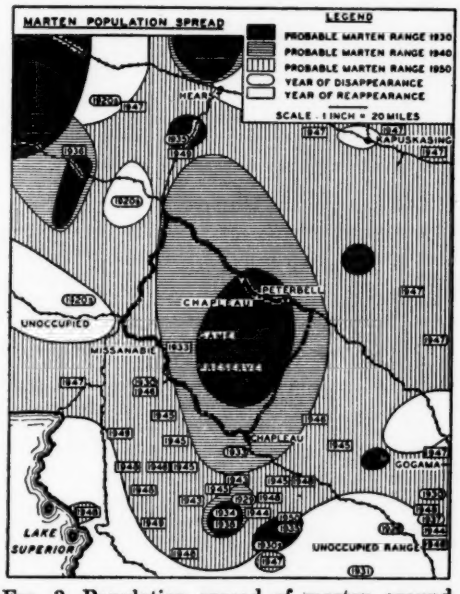


FIG. 3. Population spread of marten around Chapleau Game Preserve.

became practically trapped out from the first mentioned township around 1945, and reached a low ebb in the other ones around 1935.

The case of the fisher is slightly different. This species did not drop to such a low population level as the marten, but remained present in low numbers in a few localities (see figure No. 2). This map shows that a sizable area became restocked with fisher, but that restocking did not take place in nearly as direct a pattern away from the Preserve. Likely the more widely scattered small residual populations outside the refuge account for this to a larger extent.

Figures No. 1 and No. 2 indicate a possible influence of the habitat on the spread of both species; fisher and marten are not distributed evenly throughout the northwestern part of the District, but are more abundant in its extreme northeastern and southwestern sections than in the others. Supposing the spread of these mammals from the Preserve took place at an even rate in all directions, then they appear to have found better chances of survival and increase in some directions than in others. Extensive field surveys and a study of timber type maps of the District confirmed that indeed the habitat is more suitable where they are most common. This means that the forest is more mature, closer to the climax stage, and consists of a higher percentage of coniferous trees. A detailed discussion of habitat influences would be over long.

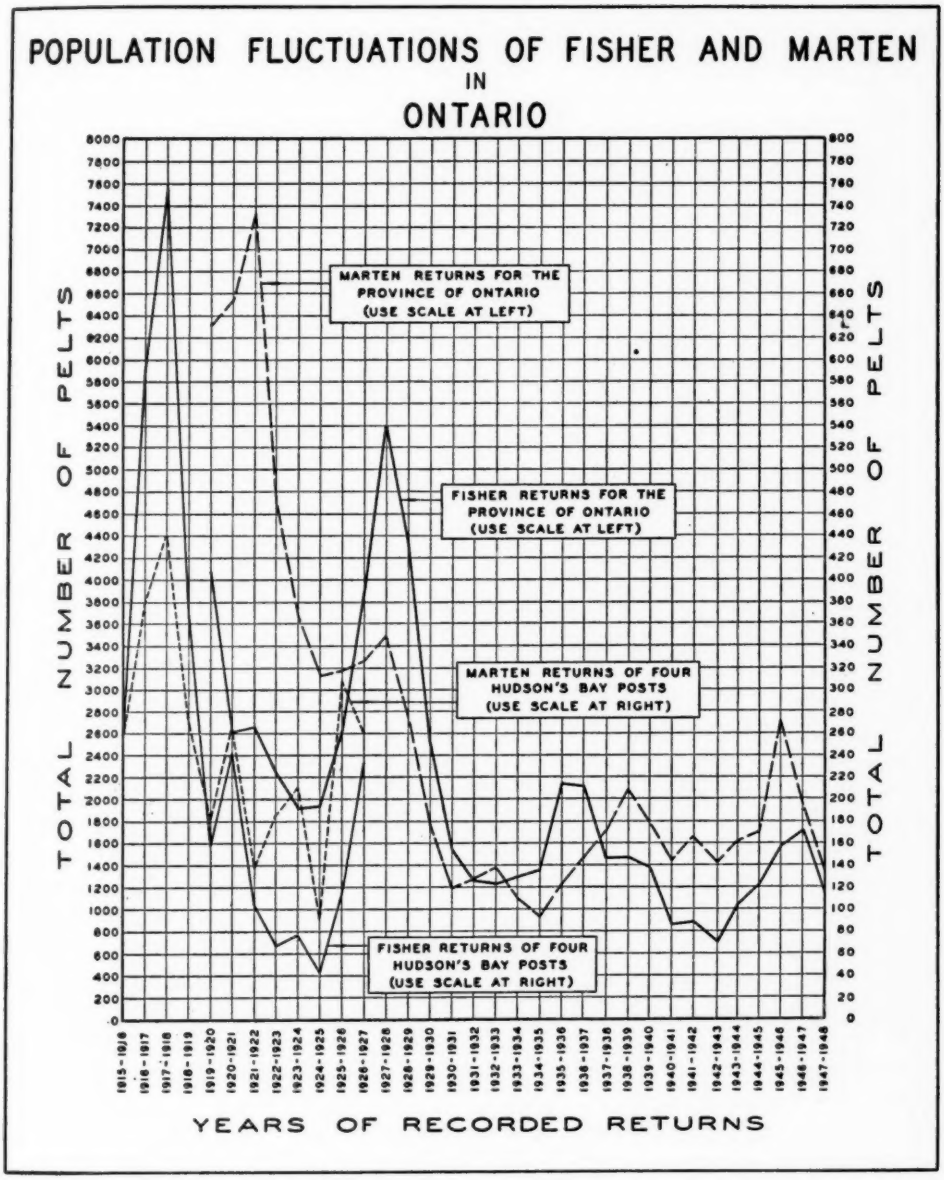
A differential density of populations might however also be caused by variations in trapping pressure and differential poaching pressure between sections. These latter factors cannot be considered to be of major importance because of the following reasons: Although there exists a difference between trappers' skill and efforts, it is unimportant as between trappers in this area and would likely average out in random fashion. As far as trappers' efforts are concerned, marten pelts were valuable enough during the period under consideration to make the effort pay. Therefore, wherever fisher and marten were known to occur, trappers would set enough traps to make sure that they would catch at least a few. Generally, they use between 40 and 100 steel traps per line to catch such furbearers as fisher, marten, mink and lynx.

Poaching pressure is hard to account for as a distorting factor. Poachers usually move into the area along the Canadian Pacific Railroad and therefore an increased pressure might be expected there. However, in the north western corner of the District there are along the railroad track just as high trappers' returns of fisher and marten as further away from it (see figures No. 1 and 2). If poaching pressure were an important influence, then there should be a noticeable difference between their populations close to and away from the track. Moreover, trapline owners generally manage to keep poachers out of their territory.

The effect of changes in market value of pelts on trapping pressure may not be considered important during the period 1941–42 to 1946–47, partly because the prices were high enough to make the trappers eager to trap both species, and partly because the prices of the pelts of both species were increasing during this period and therefore

covariant with increases in populations throughout the period under study.

Trapper's ability to trap the two species is differential: marten are easy to trap and the average trapper will not have much difficulty in obtaining them, if they are present. Fisher are, however, more difficult to trap and there is a


POPULATION FLUCTUATIONS OF FISHER AND MARTEN
IN
ONTARIO
TOTAL NUMBER OF PELTS
TOTAL NUMBER OF PELTS
MARTEN RETURNS FOR THE PROVINCE OF ONTARIO (USE SCALE AT LEFT)
FISHER RETURNS FOR THE PROVINCE OF ONTARIO (USE SCALE AT LEFT)
MARTEN RETURNS OF FOUR HUDSON'S BAY POSTS (USE SCALE AT RIGHT)
FISHER RETURNS OF FOUR HUDSON'S BAY POSTS (USE SCALE AT RIGHT)
YEARS OF RECORDED RETURNS

GRAPH 1. Population fluctuations of marten and fisher in Ontario.

TABLE 1.—FISHER AND MARTEN RETURNS CLASSIFIED IN ZONES OF 5 MILES WIDTH AROUND CHAPLEAU GAME PRESERVE

	1941–42	*42–43*	*43–44*	*44–45*	*45–46*	*46–47*	*Totals*
Zone 0–5 miles							
Marten pelts	13	29	26	20	56	56	200
Fisher pelts	10	4	5	4	11	14	48
Twps. trapped	7	6	7	7	8.5	11	46.5
Zone 5–10 miles							
Marten pelts	15	22	10	7	33	52	139
Fisher pelts	2	1	–	8	10	11	32
Twps. trapped	4.5	5	4	6	7	9	35.5
Zone 10–15 miles							
Marten pelts	24	11	18	28	46	43	170
Fisher pelts	–	2	2	7	9	15	35
Twps. trapped	6.5	7.5	7.5	9.5	10	13	54.0
Zone 15–20 miles							
Marten pelts	–	–	–	2	27	49	78
Fisher pelts	–	1	1	3	1	7	13
Twps. trapped	4	5	5	5	5	8	32
Zone 20–25 miles							
Marten pelts	1	–	1	–	7	16	25
Fisher pelts	–	1	–	3	3	5	12
Twps. trapped	5	5	3	4.5	7.5	7.5	32.5
Zone 25–30 miles							
Marten pelts	–	1	27	19	10	22	79
Fisher pelts	2	4	5	13	5	9	38
Twps. trapped	6	7	8	7	7	10	45
Zone 30–35 miles							
Marten pelts	2	–	7	9	7	7	32
Fisher pelts	4	2	5	3	5	7	26
Twps. trapped	6	7	8	9	9	9	48

difference in trapper's ability in respect to this species. It seems likely that this difference is distributed at random.

World War II apparently had no influence. As can be seen in table No. 1, approximately the same number of trap-lines were trapped during as before and after the war.

The influence of population cycles on the increase and spread of marten and fisher may be considerable. Hewitt has shown on the basis of Hudson's Bay returns for Canada, that both species have approximately a 10 year cycle. Cyclic highs for marten according to the Hudson's Bay Company totals appear to be present in the years 1867, 1876, 1887, 1896, and 1904, which indicates a 10 year cycle. A possible peak has occurred in 1926, but since then the population level has been so low throughout Canada that cyclic behaviour has been obscured. Provincial returns for the period 1920–1948 suggest weak peaks for 1939 and 1946 (see graph No. 1). An analysis of the combined total of the Hudson's Bay Posts' returns of Biscotasing, Gogama, Missinabie and Mobert suggests the presence of peaks in the years 1917–18 and 1925–26, (see graph No. 1), which coincides with the peaks for the whole of Canada. Experienced local trappers, who have trap-lines in localities where marten never disappeared, reported peak populations in the winter of 1935–36. Projecting the cycle curve beyond these recorded highs, it seems likely that the last possible peak occurred sometime around 1947.

Cyclic highs for fisher, according to the Hudson's Bay Company total for Canada, appear to be present in the years 1891, 1899, 1909, 1917, 1927 and 1936, again indicating a 10-year cycle. Provincial returns for the period 1920–1948 suggest a strong peak in 1928 and weak peaks in 1936 and 1947 (see graph No. 1). An analysis of the Hudson's Bay Posts' returns of Biscotasing, Gogama, Missanabie and Temagami suggests the presence of peaks in the years 1917–18 and 1926–27, which again coincides with the peaks for the whole of Canada. Experienced local trappers reported a peak for 1935–36. For example, Mr. M. Nyman of Fire River informed me that he caught 21 fisher in that season, while his normal catch is 4 or 5.

The above suggests that the increases noticed for fisher and marten during the period 1941–42 to 1946–47 may be partially or entirely due to a cyclic build-up and that the increase in the Game Preserve may not have been the result of protection, but may have been influenced by cyclic increases. However, even though the cyclic uptrend were the causitive factor of the noted increase of populations in the Game Preserve as well as in surrounding areas, it would not give an adequate explanation of a considerable, directed overflow from the Preserve, as compared with the practical or entire absence of overflow from residual pockets outside this refuge (see fig. No. 3). The population spread therefore seems to be due to the beneficial effects of protective measures in the Preserve.

In order to investigate the possibilities of a progressive spread of fisher and marten from the Game Preserve, township-trap lines were grouped into a series of seven concentric zones each 5 miles wide around it. Each township was allocated on the basis of the measured distance from its center to the nearest boundary of the Game Preserve. All those townships with centers situated 0 – 5 miles from the nearest boundary of the Game Preserve were

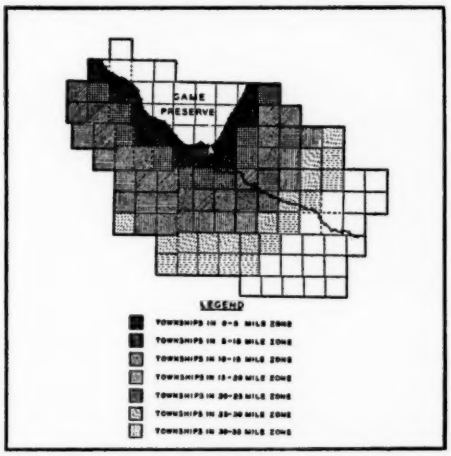
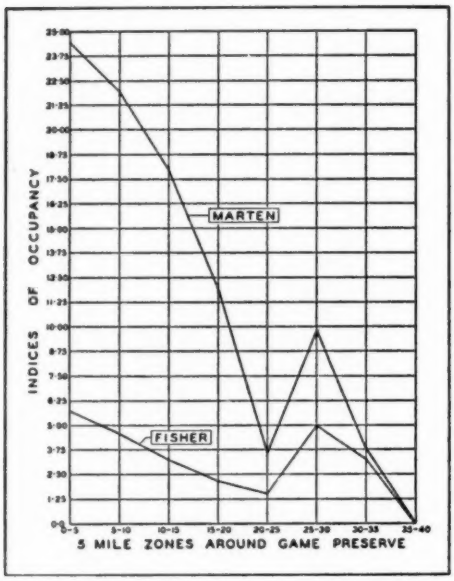


FIG. 4. Seven 5 mile wide zones around Chapleau Game Preserve.

classified in the 0 – 5 miles zone, and so forth, (see figure No. 4). Subsequently the number of townships trapped and the total number of pelts taken in each of them in seven zones were tabulated for each year of the period under consideration. This gives the returns for a broad area 35 miles in width around the southern portion of the Chapleau Game Preserve. No zonal returns further away were investigated, because marten and fisher were practically absent south and east of the outermost zone in 1947.

Table No. 1 shows the data compiled. These were submitted to Mr. L. M. Morrison, Statistician with the Department, who made a statistical analysis.

A regression line was fitted showing graphically the harvest and analytically the significance of the algebraic coeffi-



GRAPH 2. Trappers' returns grouped in 5 mile zones around the Game Preserve.

cients which state this line, (see graph No. 2). The occupancy is indicated by an index which is the evenly weighted sum of the ratios of animals trapped per township, one ratio being available for each of 6 years. It is here assumed that occupancy is shown by success in trapping. No variation has been abstracted for years. The method of analysis is a fit by orthogonal polynomials of least squares (A. C. Aitken's method) to the trend indicated by the indices of occupancy of the zones, successively receding from the protected area in 5 mile intervals.

In the case of marten the equation was:

$$Y = 13.359 - 1.797T_1(x) + .114T_2(x) + .048T_3(x)$$
$$SY^2 = 1669.01270$$

$$\text{and } t_0 = \frac{13.359}{8.37\ \sqrt{.1428}} = 4.313, \text{ significant at 1\% for 6 degrees of freedom.}$$

$$t_1 = \frac{1.797}{3.41\ \sqrt{.0089}} = 5.607, \text{ significant at 1\% for 5 degrees of freedom.}$$

$$t_2 = \frac{.114}{3.47\ \sqrt{.0013}} < 1, \text{ not significant}$$

$$t_3 = \frac{.48}{3.78\ \sqrt{.0004}} < 1, \text{ not significant}$$

So a straight line hypothesis was adopted.

In the case of fisher the equation was:

$$Y = 3.66 - .151T_1(x) + .087T_2(x) - .010T_3(x) - .029T_4(x) - .025T_5(x) - .022T_6(x)$$
$$SY^2 = 107.72750$$

Here all the coefficients except the first one fail to reach, or even approach any accepted level of significance.

The data on marten prove beyond any doubt that an overflow and a progressive falling off in abundance away from the Game Preserve exist. The ones on fisher fail under formal statistical tests to establish that the supposed effect exists. This does not mean that the effect is absent, merely that we have failed to show it. Inspection of the two sets of data show marked similarities in pattern, although they conform in a manner which is quantitatively different.

The principle of overflow from the Game Preserve and falling off of population density progressively away from

TABLE 2.—INDICES OF OCCUPANCY FOR FISHER AND MARTEN

Zones	*Index of Occupancy* †	
	Fisher	*Marten*
Adjacent to 5 miles	5.76	24.48
5 – 10 miles	4.62	21.89
10 – 15 miles	3.25	18.00
15 – 20 miles	2.17	11.93
20 – 25 miles	1.54	3.59
25 – 30 miles	5.00	9.86
30 – 35 miles	3.25	3.76

† This index is the evenly weighed sum of the ratios of animals trapped per township.

it is shown by a peak in the adjacent zone with a gradual drop up to 25 miles in case of both species, (see graph No. 2). In the zone 25–30 miles however, both species show a rise, and a subsequent drop in the zone 30–35 miles. (In the 35–40 mile zone no marten or fisher were trapped.) The residual population which survived in the mentioned townships 9H, 10H, 9G, and 10G explains the rise in the 25–30 mile zone. As this pocket was apparently not too heavily trapped, (it is trapped by an Indian family which is careful not to deplete its trap-line) it managed to increase in area inhabited by, and in number of marten and fisher (see figures No. 1, 2 and 3). During the six year period under consideration, 11.9 per cent of the total marten catch of the District were caught in these 4 townships, which is an indication of the relative high abundance of the species in this pocket.

Increases of fisher and marten populations were found to be different in the areas close to from those remote from the Game Preserve. The pertinent data are combined in table No. 3.

Percentages were computed by dividing the number of animals caught in 1946–47 by the number caught in 1941–42, for example $\frac{1.25}{1.04} = 1.20$, or an increase in population of 20 per cent. Data were obtained from those contained in table No. 1.

The figures show that fisher and

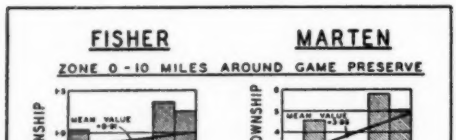
TABLE 3.—DIFFERENTIAL INCREASES OF FISHER AND MARTEN POPULATIONS

Distance from the Preserve	Trapping Season	Fisher caught per unit trap-line ‡[2]	Marten caught per unit trap-line
Zones 1 and 2	1941–42	1.04	2.43
(0–10 miles) ‡[2]	1946–47	1.25	5.04
Increase in number of pelts caught, comparing the 1946–47 catch with that of	1941–42	20%	107%
Zones 4 and 5	1942–43 ‡[4]	.40	.11 (1941–42)
(15–25 miles)	1946–47	.76	4.19
Increase in number of pelts caught, comparing the 1946–47 catch with that of	1942–43 ‡[4]	90%, and of 1941–42: 3709%	

‡[2] Data of 2 zones were "pooled" in order to increase the returns of pelts to more significant numbers.

‡[3] By "unit trap-line" is meant a trap-line of one township.

‡[4] The trapping season 1941–42 could not be selected in this case because no fisher were trapped in that year.


FISHER
MARTEN
ZONE 0 - 10 MILES AROUND GAME PRESERVE
ZONE 15 - 25 MILES AROUND GAME PRESERVE
No. OF PELTS PER UNIT AREA OF ONE TOWNSHIP
UNIT AREA OF ONE TOWNSHIP
No OF PELTS PER
MEAN VALUE
THEORETICAL INCREASE
TRAPPING PERIOD

GRAPH 3. Differential population increases in zones close to and away from the Game Preserve.

marten increased considerably more in the 15–25 mile zone than in the 0–10 mile area, if comparing the initial with the final populations in the period under study.

Histograms were prepared to show this differential increase for each year throughout the entire six years' period, (see graph No. 2). It can be noticed that their shapes are very similar for both species. They indicate that in the 0–10 mile zone there were relatively high, and in the 15–25 mile zone low initial populations and also that differential increases took place in the zones. When drawing a theoretical line of increase, one notices that in case of the fisher there is a greater increase in the 15–25 mile zones as compared with the 0–10 mile one, than in case of the marten. Actually, this hypothetical line of increase is in case of the latter species only slightly steeper in the 15–25 mile zone than in the other zone. This might indicate that the fisher population was nearer to a saturation level in the zone close to the Preserve than the marten.

The figures and histograms presented may indicate that there was considerably more influx of both species in the more remote zones than in the ones close by the Preserve. However, according to the logistic equation of population growth, the expected increase in population through reproduction alone would vary with the initial population level and the gain (in terms of percentages) would be very much slower at higher levels. Although this agrees with the above findings, it does not sufficiently explain the substantial increases in the population of marten in the zone 15–25 miles from the Preserve: while in this zone only 2 martens were caught in 1944–45, 34 were trapped in 1945–46 and 65 in 1946–47. This increase is more than one would normally expect from the logistic equation of population growth and, as there is no known reason for expecting a differential reproduction, it may be assumed to be at least partly due to influx.

SUMMARY

Trappers' fur returns were analysed in order to find indications of a possible overflow of fur-bearers from Chapleau Crown Game Preserve. Strong indications of such an overflow were found in case of the marten and fisher.

Statistical analysis of the data concerning these two species prove that an overflow and a progressive falling off in abundance away from the Game Preserve exists in case of the marten. This could not be proven formally in case of the fisher. However, inspection

of data show marked similarities in pattern for both species, namely a fall from a peak while progressing away from the Preserve. A second slight peak is caused by a surviving population outside the sanctuary.

Data presented indicate that in 1941 there were relatively high populations of both species in the zone adjacent to the Preserve as compared to low ones more remote from it. While during the period 1941–1947 a steep increase in population took place in the latter zone, this phenomenon was far less noticeable in the former. Consequently, remote areas have a more rapid increase in population than the already populated ones. As this increase is greater than expected by the logistic equation of population growth, and as there is no known reason for expecting a differential reproduction, the differential increase is assumed to be partly due to influx.

Cyclic fluctuations are noticeable in the relatively low marten and fisher populations observed.

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Accepted for publication June 23, 1950.

THE AGING OF MUSKRATS ON THE MONTEZUMA NATIONAL WILDLIFE REFUGE[1]

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Introduction

One of the basic properties of any wildlife population is the species productivity, which has been defined by Leopold (1933, p. 22) as ". . . . the rate at which mature breeding stock produces other mature stock, or mature removable crop." Any means of determining this productivity is of considerable value to the wildlife manager as a combined indicator of the success of the breeding season and the effect of the mortality factors on the resulting population between the time of birth and the harvest period.

To accurately determine this productivity, it would be necessary to trap and mark several litters or broods and follow them through the entire season. In attempting to avoid this lengthy and expensive process of obtaining productivity figures, several techniques

[1]A portion of a thesis presented to the Graduate Committee of the New York State College of Forestry in partial fulfillment of the requirements for the degree of Doctor of Philosophy, September, 1949.

[2]The writer wishes to acknowledge the helpful advice and assistance given by the staff of the Department of Forest Zoology, New York State College of Forestry and the necessary cooperation given by the U. S. Fish and Wildlife Service, particularly Refuge Manager Merton Radway.

have been devised in the past few years which can be used in the separation of the various age classes, particularly the young of the year and the adults, for several different species of wildlife. If this classification can be done, the number of young produced to maturity can be calculated for each breeding female. The best possible time to attempt such classification is during the harvest period when it would be relatively inexpensive and not too time consuming. The technique used should be simple in method, requiring little experience, quick in its application, cheap in obtaining the necessary data, and of a nature that would lend itself to fast and easy analysis and interpretation. Leopold (1947) speaks of these aging techniques as new and of basic importance. However, animal ecologists have recognized for some time the fact that the investigation of age distributions was a neglected study (Allee, *et al.*, 1949).

The aging of the muskrat (*Ondatra zibethica*) is not as easy as one might believe. This is due to the fact that most of the young of the year are sufficiently large by the beginning of the trapping season to fall within the limits of variation of the adults, particularly when considered from the standpoint of gross size and weight. Within the past ten years, several methods have been devised for the determination of the age of muskrats. These have used such characters as size and appearance of the internal reproductive organs (Errington, 1939), size and appearance of the external genitalia (Baumgartner and Bellrose, 1943), length of pelt (Lay, 1945), incisor width (Sooter, 1946) and pattern of primeness of the pelt (Kellogg, 1946; Applegate and Predmore, 1947; Shanks, 1948).

THE MONTEZUMA STUDY

A study of the muskrat was started in the late fall of 1947 on the Montezuma National Wildlife Refuge, Seneca Falls, New York. This is a 5,819-acre waterfowl refuge containing considerable areas suitable as muskrat habitat. There are two major impoundments on the Refuge, the first of nearly 1,600 acres flooded in the spring of 1942 and the second of approximately 1,200 acres flooded in the spring of 1943. Some of the area included in the first impoundment was supporting a good muskrat population before the time of flooding. The remainder of the flooded areas varied from cordgrass meadows to red maple swamps. Therefore, after flooding had been completed, the areas could be divided into several distinct units, each undergoing rapid plant succession but in a different stage of development. The muskrat population on each trapping unit was seen to build up, level off and gradually decline to a more stable condition. At the time of this study all but the last of five units had completed or nearly completed this build up and decline of their population.

During the 1948 trapping season (January 1 to March 20), a sample of 552 muskrats was taken from the trappers' catch. This was accomplished by regular visits to the Refuge, approximately one week apart, and on such visits all of the catch for that day was obtained for the sample. Due to the catch becoming smaller as the season progressed, the distribution of the sample was 340 in January, 134 in

February and 78 in March. The muskrats were numbered, sexed, weighed, measured and aged. The ages were determined by the size and appearance of the external genitalia. The carcasses were then frozen and placed in cold storage until time permitted their examination. Several measurements then were taken including the length, width and thickness of the gonads. The color and appearance of the testes were recorded and, in the females, the thickness of the uteri and the number of placental scars. The head was removed and the skull cleaned and bleached. Measurements were taken before the skulls became dry and also after shrinkage had taken place. The skull measurements included condylobasal length, zygomatic breadth, and cranial width. The cranial weight of the dry skull was also taken.

From this information, three types of data were used in aging each specimen. These are (1) size and appearance of the external genitalia, (2) size and appearance of the internal reproductive organs and (3) appearance of the skull including massiveness, development of the lambdoidal crest, fusing of the sutures and the appearance of the dentition. No attempt was made to use the other aging methods.

In most cases positive aging was not difficult. Where conflicts occurred, further study was made of the specimen and the final age was determined by the strongest evidence. However, 11 of the 552 could not be aged. Of the 541 aged, 392 were subadults and 149 adults. It is expected that some error might still exist but it is believed to be at a minimum. A few barren females may have been classified as subadults instead of adults. The term subadult is used to mean the young of the year which are approaching maturity at the time of harvest.

Analysis of Aging Techniques

An analysis was made of the two principal methods used in aging the sample: the size and appearance of the external genitalia and the size and appearance of the internal reproductive organs. In addition to this, three methods of determining age were studied in detail and given statistical analysis of variance. These were total weight, body length, and zygomatic breadth. It was desirable to make the comparisons of these three methods equitable and to insure this, any individual of the sample that did not have all three measurements was not used. Then to further simplify the analysis and to correct for nonrepresentative factors, such as sex ratio, an equal number was selected for each sex, age and unit of the marsh. Seven was the largest number that could be extracted from each and so this number was selected randomly through the use of a table of random numbers (Snedecor, 1946). In the analysis of both sexes, two ages, and five units this would total a sample of 140 individuals instead of the original 541 aged muskrats. It was believed that this would be a sufficiently large sample. A triple interaction analysis of variance was then calculated according to Snedecor (l.c.).

Size and Appearance of the External Genitalia—The method described by Baumgartner and Bellrose (1943) was used in aging 521 muskrats from the sample before pelting. When these results were compared with the final age

determinations, 145 or 27.8 per cent were found to be erroneously aged. This reflects to a degree the operator's inexperience with the application of the method. However, probably a greater source of error is the nearness to the breeding season. Breeding usually begins in the first part of March and it was found that 43.7 per cent of those aged in this month were in error. It also was found that 89.7 per cent of the 145 muskrats erroneously aged were subadults classified as adults. This substantiates Baumgartner and Bellrose's (l.c.) statement that prior to and during the breeding season many of the subadults develop adult external genitalia characteristics. This would be particularly true in the females due to the opening of the genital orifice at this time.

It is believed that after a little practice in the use of this technique and its check with other methods, it could be used through the month of January in New York State with fair success.

Size and Appearance of the Internal Reproductive Organs—Errington (1939) in his work on the development of the muskrat clearly explains the differences that exist between the young of the year and the adults with emphasis on the size and appearance of the reproductive organs. From this he establishes criteria which will separate the two ages of Iowa muskrats during the fall and early winter. In the use of this method on the Montezuma muskrats, consideration had to be given the fact that their size is somewhat greater and the season is later in the winter.

It was found that 297 of the 541 aged were males. Four more obtained after the close of the regular season made the total 301. The average testis lengths for all individuals were grouped by half-month periods so that comparisons could be made between the two age classes throughout the season. Considerable overlapping was noted especially in the latter part of the season.

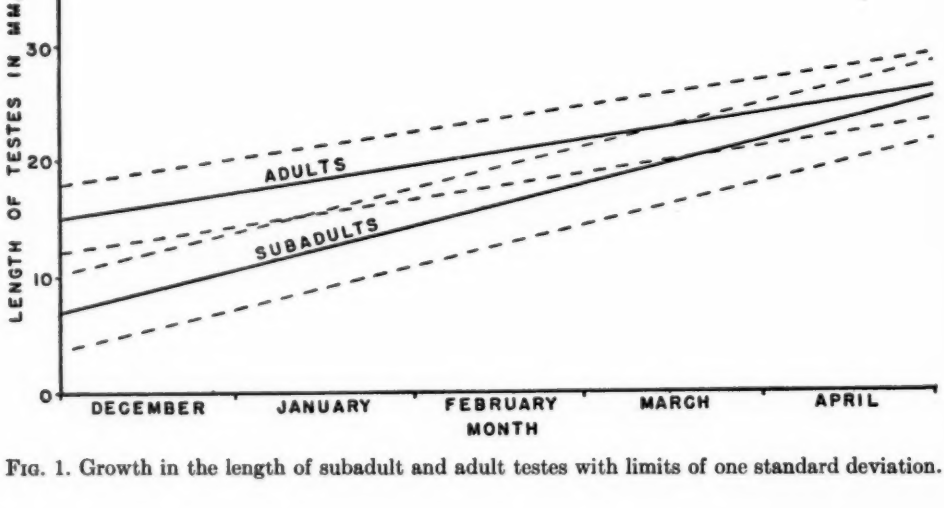

FIG. 1. Growth in the length of subadult and adult testes with limits of one standard deviation.

As the season progressed from January to March, the testes of the young were growing quite rapidly and the testes of the adults were swelling to their former size. Therefore, as the breeding season approached the variation between adults and subadults became smaller and the reliability of the method became greatly reduced.

A regression line was plotted for each age, extended at either end and showing the limits of one standard deviation (Fig. 1). This shows the potential value of the method in the fall and early winter but also shows that there is not enough difference between the ages to permit its use in late winter or early spring.

The separation of the ages of the female muskrats by internal reproductive organs was not as difficult. Those having the placental scars of previous litters were adults and those with thin, translucent uteri were subadults. However, possible error was present in the classifying of barren adults as subadults. This error should be small.

Total Body Weight—The use of total body weight in separating the young of the year from the adults has been frequently used although it has been known by others to be of little value (Baumgartner and Bellrose, 1943). Its use is limited to only the separation of the extremely light as young from the extremely heavy as adults. There is extensive variation within each age group depending on the time of year, the habitat and available food.

No value was placed on this method in this study but an analysis of the data was made to further disprove its usage.

The weight of each of the 140 individuals used in the analysis of variance were converted to ounces and these were tabulated according to sex, age and unit. The analysis of variance is shown in Table 1.

In applying the F test the variation between ages and between units are found to be highly significant. Also the interaction variation of age and units is significant. However, it is necessary to further isolate the variance before any statement can be made on the reliability of weights as an indicator of age or units. To do this it is necessary to determine what is included in each mean square and then calculate the components of variance. This gives the true variance due to any single factor, but it is always combined with others in nature so that it can be isolated only through statistical means. It shows the influence that this age variance has on the mean square. In this instance the variance due to age is only slightly

TABLE 1.—ANALYSIS OF VARIANCE—TOTAL WEIGHT

Source of Variance	Degrees of Freedom	Sum of Squares	Mean Squares	F	Components of Variance	
Total	139	11,123.14				
Bet. Ages	1	3,288.29	3,288.29	73.51**	σA^2	=46.2744
Bet. Sex	1	151.19	151.19	3.38	σS^2	= 1.9900
Bet. Units	4	1,275.38	318.85	7.13**	σU^2	= 7.6175
Age X Sex	1	15.41	15.41	0.34	σAS^2	=−1.7143
Age X Units	4	436.30	109.08	2.44*	σAU^2	= 2.4050
Sex X Units	4	287.48	71.87	1.61	σSU^2	=−0.2514
Age X Sex X Units	4	301.64	75.41	1.69	σASU^2	= 4.3829
Individuals	120	5,367.45	44.73		σ^2	=44.7300

greater than the variance occurring in the individuals. Also, the true variance between units is very small in comparison to individual variation. The variation between individuals being nearly as great as between ages and between units renders this method of little value. Average weights can give some indication of the conditions to be found in the different units when the total population or the catch is considered, but from the standpoint of individuals their variation is too great for weights to be of any value.

Body Length—When examination was made of the different body measurements, it was found that total length expressed the greatest difference between the ages. To eliminate irregularities of the tail, its length was deducted from the total length to give body length. This also would be more comparable to the pelt length as used by Lay (1945) in the aging of Louisiana muskrats.

The same individuals used in the analysis of total weight were used in this analysis. The body length of each of these was converted to eighths of an inch. The analysis of variance is shown in Table 2.

When the F test is applied, the results are similar to those for total weights. Both the variation between ages and between units are highly significant while the interaction of ages and units is significant. When the true variance for each is statistically isolated, it is found that here again the variation among the individuals of any subclass is nearly as great as that between the ages. The mean square for between ages is made up of many components other than age and these are sufficiently large to render the method of little value in aging muskrats. The components of between units, and age and units are both small and overshadowed by individual variation.

As a result of this analysis, it can be said that body length and probably all other external measurements are of no value in aging individuals. Averages for a large number will show differences between ages.

Zygomatic Breadth—Two skull measurements were given consideration in this study. These were the condylobasal length and the zygomatic breadth. (Fig. 2). They were taken shortly after the skulls were cleaned and bleached and again after the skulls had undergone shrinkage.

It was noted that there was considerable difference between the two ages. This led to the careful examination of these measurements as a possible means of age determination. Inasmuch as the

TABLE 2.—ANALYSIS OF VARIANCE—BODY LENGTH

Source of Variance	Degrees of Freedom	Sum of Squares	Mean Squares	F	Components of Variance	
Total	139	6,848.4				
Bet. Ages	1	2,255.4	2,255.4	87.75**	σA^2	=31.2071
Bet. Sex	1	86.4	86.4	3.36	σS^2	= 0.6443
Bet. Units	4	843.0	210.8	8.20**	σU^2	= 5.2393
Age X Sex	1	41.9	41.9	1.63	σAS^2	= 0.1771
Age X Units	4	258.8	64.7	2.52*	σAU^2	= 2.0714
Sex X Units	4	140.2	35.1	1.37	σSU^2	=-0.0429
Age X Sex X Units	4	142.7	35.7	1.39	σASU^2	= 1.4286
Individuals	120	3,080.0	25.7		σ^2	=25.7000

most practical method was desired, only the zygomatic breadth was analysed. The zygomatic arches lie almost at the surface, being covered by only a thin layer of tissue and so can be measured as soon as the animal is pelted. The condylo-basal length appeared to be about as good a character but would require considerable work in preparing the skull before the measurement could be taken.

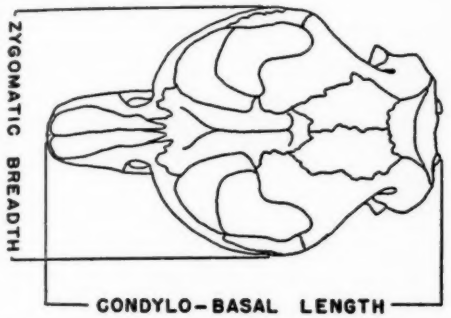

FIG. 2. Dorsal view of a muskrat skull showing the location of the measurements, zygomatic breadth and condylo-basal length.

A search was made of the literature and it was found that Clark (1941) had made a statistical study of several species and subspecies of *Peromyscus* and had found that the zygomatic breadth was the least variable of all measurements with skull length nearly equaling it. Body measurements were more variable especially the tail length.

Before this, Latimer and Riley (1934) had made a study of skull and long bones of the muskrat in Kansas (*O. z. cinnamomina*). Thirteen measurements were taken on 124 specimens and it was found that the skull breadth (cranial width), skull length (condylo-basal length) and bizigomatic diameter (zygomatic breadth) had coefficients of variation of 2.75, 3.92 and 4.87, respectively. These measurements were taken on mature individuals based on the closure of the epiphyseal cartilage and so may include some subadults. This would give greater variation to the measurements.

Gould and Kreeger (1948) published their work on the skull measurements of 357 old-age Louisiana muskrats (*O. z. rivalica*) during the time that the Montezuma study was in progress. They found the coefficient of variation for cranial width, skull length and zygomatic breadth to be 3.68, 4.05 and 4.43 per cent, respectively.

An analysis of the zygomatic breadth was made for the measurements taken before and after shrinkage had taken place but the results were similar. The measurements taken before shrinking are more representative of the fresh specimen and so will be used here. The analysis of variance of these measurements is given in Table 3.

TABLE 3.—ANALYSIS OF VARIANCE—ZYGOMATIC BREADTH

Source of Variance	Degrees of Freedom	Sum of Squares	Mean Squares	F	Components of Variance	
Total	139	630.64				
Bet. Ages	1	372.61	372.61	237.33**	σA^2	= 5.2557
Bet. Sex	1	1.28	1.28	0.82	σS^2	=−0.0034
Bet. Units	4	26.20	6.55	4.17**	σU^2	=−0.0264
Age X Sex	1	0.27	0.27	0.17	σAS^2	=−0.0380
Age X Units	4	24.15	6.04	3.85**	σAU^2	= 0.3171
Sex X Units	4	11.38	2.85	1.82	σSU^2	= 0.0893
Age X Sex X Units	4	6.41	1.60	1.02	σASU^2	= 0.0043
Individuals	120	188.34	1.57		σ^2	= 1.5700

It will be noted that variance between ages, between units and the interaction of age and units are all highly significant. However, the components of variance show that the true variance for between ages is about 3.5 times the variance for individuals and that the remaining components are all near zero. This would mean that any variation found would be due largely to age. Although the variance between units is highly significant, the component for units is near zero. This is due to the differences in ages in the different units. The older habitats have a large proportion of adults while the newer habitats have a smaller proportion of adults. When all habitats become stabilized, the between-unit variance should lose its significance. This relationship of units and age also causes the interaction variance of age and units to be highly significant.

Recently Hooper and Ostenson (1949) have published their findings on the aging of otter in Michigan. They list the zygomatic breadth as the least variable of the skull measurements within any age and state that it is the most accurate measurement that can be used in estimating age.

It is felt that this method might not only separate the subadults from the adults but might also aid in the separation of the litters of the young and the year age classes of the adults. The zygomatic breadth of the 126 adults and 328 subadults are plotted by 0.2 mm. classes in Figure 2. This class interval was used to help eliminate any personal error in reading the vernier caliper to the nearest 0.1 mm. The measurements taken after the skulls had completed their shrinkage are plotted in Figure 3. The latter will be used only in aiding the interpretation of the former.

There is an expected amount of overlap between the two ages. This is divided equally on either side and so the use of zygomatic breadth measurements would not change the true age ratio. The coefficient of variation in per cent is 3.62 for the subadults and 3.17 for the adults. This is somewhat lower than that given by other investigators.

In the curve representing the sub-

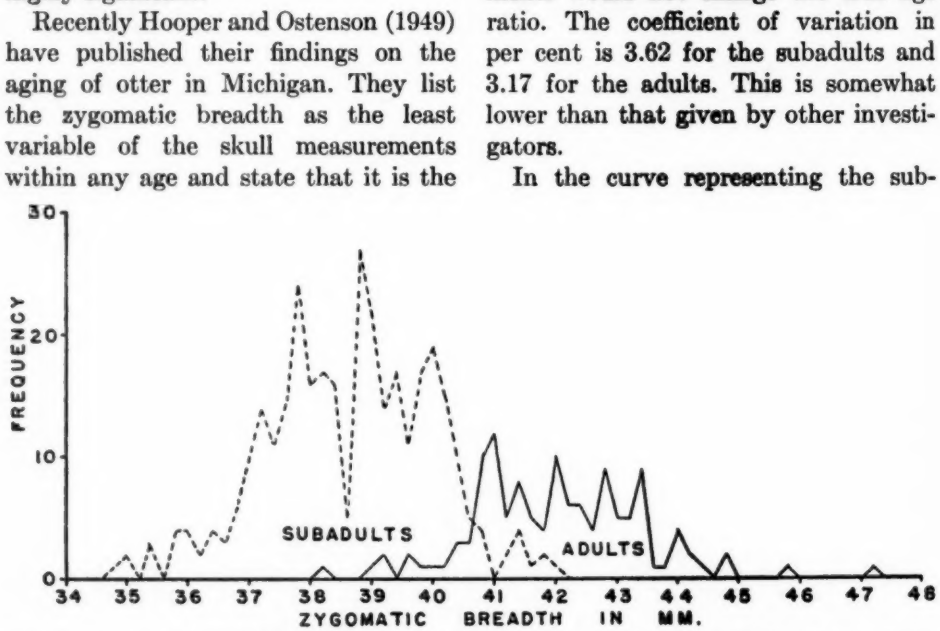

FIG. 3. Zygomatic breadth of 454 muskrat skulls measured shortly after cleaning, 1948 season.

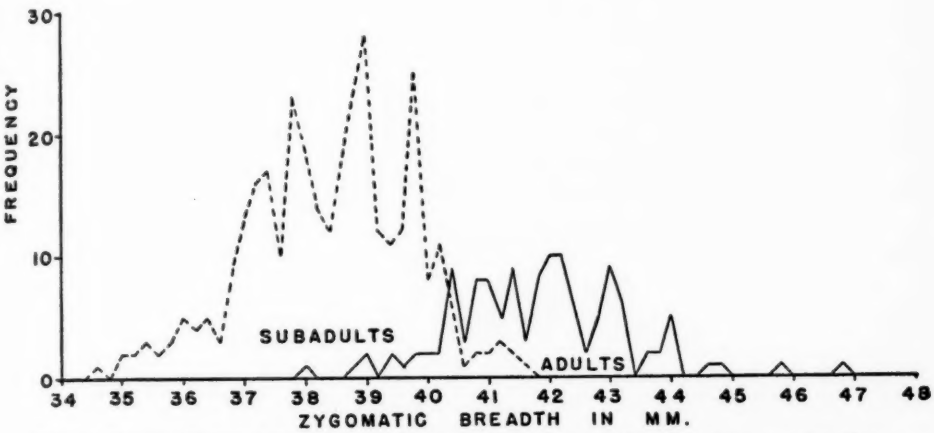

FIG. 4. Zygomatic breadth of 454 muskrat skulls measured after shrinkage was complete, 1948 season.

adults (Fig. 3) there are two definite areas of increased frequency separated by a narrow low frequency area at 38.6 mm. This is common to all five trapping units. In Figure 4 this subadult curve is more definitely divided into four major areas and two smaller ones. This might indicate six periods of litter production. Although the returns from tagged specimens were very meager, they tend to indicate that these six peaks are probably spaced about a month apart, the first one occurring near the end of April and continuing to the smallest in September. This does not mean that six litters are produced by a single female although it might be possible if mating followed parturition throughout the summer. A possible record of this activity was made on the Refuge during the summer of 1948. A litter of five, estimated to be 2 or 3 days old, was removed from a house and not returned. The house was not damaged and 32 days later was revisited and again five young muskrats, 2 or 3 days old, were found in the same nest. This might account for the monthly interval, part of the females breeding immediately and part after the first litter has been weaned, approximately a month later. The number of young per litter is variable but based on four litters, one set of embryos and six sets of placental scars obtained in the summer of 1948, the average litter size would be 5.6. The placental scars were counted for the adult females included in the sample taken during the 1948-season. The total count of scars for the 70 adult females was 1,020 or an average of 14.6 per female, ranging from 0 to 24. Sooter (1946) made placental-scar counts on 100 adult females from Tule Lake Refuge, California, and obtained an average of 14.05 scars per female with a range from 0 to 26. By dividing the average number of placental scars by the expected size of litter (5.6), the number of litters per season is determined at 2.6. From this it can be interpreted that most females have two litters per year and that some have a third litter. It is of interest to

note that the litter size (5.6) is identical to the ratio of subadults to adult females in the harvest. This indicates a 62 per cent mortality from birth to midwinter.

The adults were more difficult to separate into subgroups but with the aid of two tagged adults and the measurements after shrinking, tentative divisions were made. After study of these data, another curve was constructed (Fig. 5) which is a suggested distribution of the several age groups in the winter population.

Before anyone should attempt to use the zygomatic breadth as a method for aging muskrats, a sample of about 150 or more should be measured in January when the correct age can be accurately determined by internal genitalia characters. This would establish the dividing point of the two principal age groups. These measurements should be taken on the carcasses as soon as the pelts have been removed.

The dividing points between the litters and the seasons as determined for the Montezuma Refuge by this study were used in constructing the curve in Figure 5. Any borderline case should be placed in the younger group to allow for the thin membranes that might be present over the arches.

In order to test this method of aging muskrats, 155 muskrats were measured in January 1949 and checked with external genitalia characters. The most logical dividing point was again 40.6 mm., with 40.8 mm. all adults and 40.4 mm. largely subadults. Of this sample, 62.6 per cent were subadults which is lower than the 72.5 per cent for the previous year. However, 68 per cent of the 1949 subadults came from older habitats that produced 63.4 per cent subadults during the 1948-season.

Extrusion of the Lower Molars—One of the criteria used by Gould and Kreeger (1948) in the selection of old age skulls was the ". . . . visibility of the end of the fluting of the tooth as it sits in the socket." This had reference to

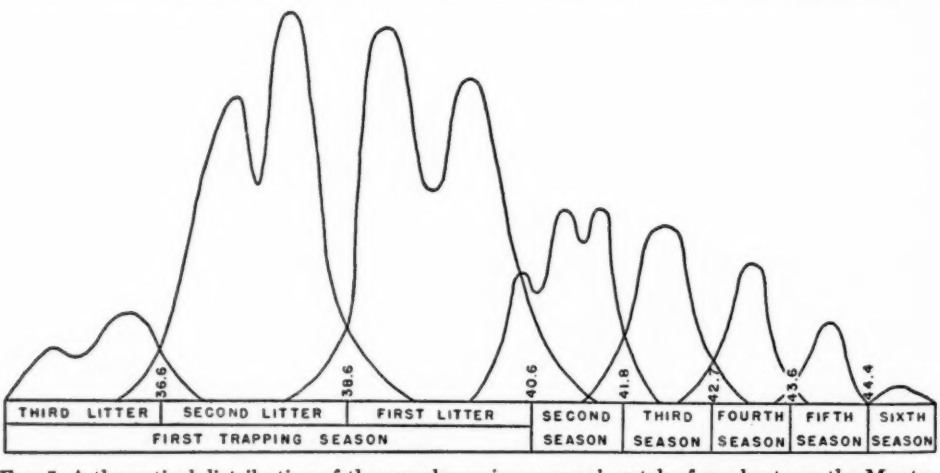

FIG. 5. A theoretical distribution of the age classes in a season's catch of muskrats on the Montezuma National Wildlife Refuge based on a sample of 454 taken during the 1948 harvest, with some modifications. The numbers indicate measurements of the zygomatic breadth in millimeters separating the various age classes.

the upper molar teeth. Upon examining the teeth of the Montezuma muskrats, it was discovered that this condition was present at a much younger age on the mandibles. After a little experience in handling specimens, it was found that one could separate the subadults from the adults with this characteristic. The subadult molars did not have the ends of the flutings visible above the bone socket. The anterior surface of the first lower molar was straight or nearly so. The first lower molars of the adult did have at least the first fluting visible above the bone socket or the end of it easily seen just below the bone line. The anterior surface of the first lower molar was curved at the base. It is believed that further study might find characteristics that would divide the adults into their year classes. The use of dental characteristics is useful, particularly when attempting to age parts of carcasses, skeletons or stomach contents.

SUMMARY

A study of techniques for aging muskrats was made on the Montezuma National Wildlife Refuge during the 1948 trapping season. A sample of 552 muskrats was taken from the season's harvest. By means of the size and appearance of the external and internal reproductive organs and general skull characteristics, 541 were classified as 392 subadults and 149 adults.

It was found that the size and appearance of the external genitalia were good characteristics in January and part of February but became poorer as the breeding season approached.

Similarly, the size and appearance of the internal reproductive organs were good characteristics in January for the males but could be used for the females throughout the season.

A statistical analysis was made of the total weight, body length, and zygomatic breadth for 140 of this sample. These were equally and randomly selected from each sex, age and trapping unit. It was found that total weight and body length were of little value in estimating age due to a high variation between individuals, nearly equaling the variation between ages.

The zygomatic breadth proved to be a measurement of little variation that would separate the subadults from the adults with a reasonable degree of accuracy. This measurement can be made on the carcass as soon as the pelt is removed. For the Montezuma Refuge, the point of division between the two age classes is 40.6 mm. There is a possibility that further breakdown of the age classes into litters and seasons is possible.

Examination of the dentition resulted in the belief that the extrusion of the first lower molar can be used as an aid in determining age. For the adults the end of the first fluting is visible above or just below the bone line and the anterior surface is curved at the base of the tooth.

The 541 aged muskrats show evidence of six periods of production during the breeding season. Information gathered from trapping returns of tagged young indicates that these peaks are about a month apart, beginning about the end of April.

From litters handled and placental scar data it is concluded that the average size of the litters is 5.6 and that an average of 14.6 are produced during

the season. This means that most females produce two litters each year and that some produce a third litter. The ratio of 5.6 subadults to each adult female in the harvest indicates a 62 per cent mortality from birth to the time of harvest.

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Accepted for publication July 5, 1950.

A STUDY OF ABSORPTION AND RETENTION OF LEAD IN WILD WATERFOWL IN RELATION TO CLINICAL EVIDENCE OF LEAD POISONING

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The incidence of lead poisoning from the ingestion of spent shot, and the consequences to waterfowl populations have been discussed by a number of workers (see Literature Cited). It has been pointed out that plumbism constitutes an important cause of loss in wild ducks and geese through direct fatalities, and indirectly by sub-acute

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poisoning resulting in sterility and subsequent failure in reproduction. However, little systematic work has been reported on the pathology of lead poisoning in these species, and there have been no published reports dealing with the determination of the quantities of lead which will produce toxic symptoms, or the rapidity with which clinical symptoms make their appearance.

In order to obtain information on these points, and to investigate the possibility of using chemical analysis of tissues as an aid in diagnosis of lead poisoning, a series of controlled experiments involving captive wild ducks was conducted. The clinical effects of sub-lethal and lethal doses of lead, and the quantities of element deposited in various tissues, were determined.

EXPERIMENTAL

All birds used in these studies were adult Mallard ducks, which had been captured in the wild. Following capture, the birds were held in isolation in a lead-free area. Selection for use in the experiment was on the basis of uniformity of weight, equal division of sexes, and normal blood pictures. Distilled water and a diet consisting of equal parts of cracked corn and wheat were supplied ad libitum. Since lead must assume a soluble form before absorption from the digestive tract, an aqueous solution of lead nitrate [$Pb(NO_3)_2$] was used throughout the experiment. To avoid loss in dosing, this solution was administered to all test birds by flexible catheter, directly into the gizzard. Dosage levels of 3, 6, 8 and 12 milligrams of lead per kilogram of body weight per day were employed, and adjustment of dose to variations in body weight was made every 5–7 days.

At the start of the experiment, 2 birds were sacrificed as "normals" for histological study and chemical analysis. Erythrocyte and leucocyte counts, and hemoglobin determinations were made on the blood of the remaining ducks just prior to the first administration of lead, and on alternate days throughout the test period. A Sahle Haemometer was used for all hemoglobin determinations.

Carcasses were examined as soon as possible following death of birds. At this time, the gastro-intestinal tract was removed, emptied, and the lumen washed. The tract was then replaced in the carcass, and the empty body weight obtained. Tissues were saved for histological examination and chemical analysis. For the purpose of lead analyses, the carcass was divided into 4 units designated as: liver, skeleton, feathers, and soft tissues. Samples were prepared for analysis by dehydration and rapid grinding in a hand mill. The lead contents were determined colorimetrically as the dithizone complex, according to the Methods of Analysis of the Association of Official Agricultural Chemists.

During the experiments, feeding tests on 4 birds were supplemented with lead metabolism studies, using a balance sheet method in which intake and excretion of lead were determined. During the collection period, the ducks were held in individual cages of wood and cloth construction, and the excreta were caught in glass receptacles.

RESULTS

Data obtained in these studies are presented in Tables 1, 2, and 3, and in Figure 1.

Gross Pathology: The primary purpose of these studies was concerned with the clinical aspects of lead poisoning, however, all birds were given a careful

TABLE 1.—LEAD INGESTION IN RELATION TO CLINICAL MANIFESTATIONS OF LEAD POISONING

Bird	Lead Administered Daily dose (mg./kg.)	No. of Doses	Total (mg.)	Survival (days)	Body Weight (gms.) Initial	Final	Erythrocytes Initial	Final	Hemoglobin (%) Initial	Final
2	8	27	111.3	29	696	545	3.51	1.21	134.5	58.1
7	8	24	130.8	24	979	419	3.66	0.68	90.1	64.9
4	8	24	149.3	29	934	521	3.03	1.46	122.0	71.8
5	8	24	155.8	24	1186	660	3.03	1.57	120.8	43.3
62	8	24	160.5	24	1060	631	3.12	1.45	102.9	29.6
18	8	41	240.6	42	970	597	2.71	1.80	93.5	43.3
Average		27.3	158.1	28.7	971	562	3.18	1.36	110.6	51.8
79	12	19	179.2	21	979	668	3.73	1.89	108.3	49.0
15	12	22	201.0	24	964	831	2.74	1.16	101.5	42.2
8	12	26	208.0	26	1007	502	3.08	1.90	98.0	33.0
19	12	23	212.4	24	1048	597	2.16	1.66	109.5	43.3
61	12	24	227.7	24	1151	507	2.17	1.59	118.5	35.3
17	12	27	230.7	31	1003	514	3.91	1.63	111.7	57.0
Average		23.5	209.8	25.0	1025	603	2.97	1.64	107.9	43.3
Grand Av. (all birds)		25.4	183.9	26.8	998	583	3.07	1.50	109.3	47.6
6	6	132	441.2	137	768	652	2.46	3.28	98.0	109.4
	12	13	85.5	14	652	450	3.28	2.54	109.4	61.5
Total		145	526.7	151						
20	6	132	628.0	137	987	973	2.73	3.71	94.6	103.7
	12	21	201.2	22	973	681	3.71	2.81	103.7	46.7
Total		153	829.2	159						

TABLE 2.—COMPARATIVE WEIGHTS AND LEAD CONTENT OF TOXIC AND CONTROL TISSUES

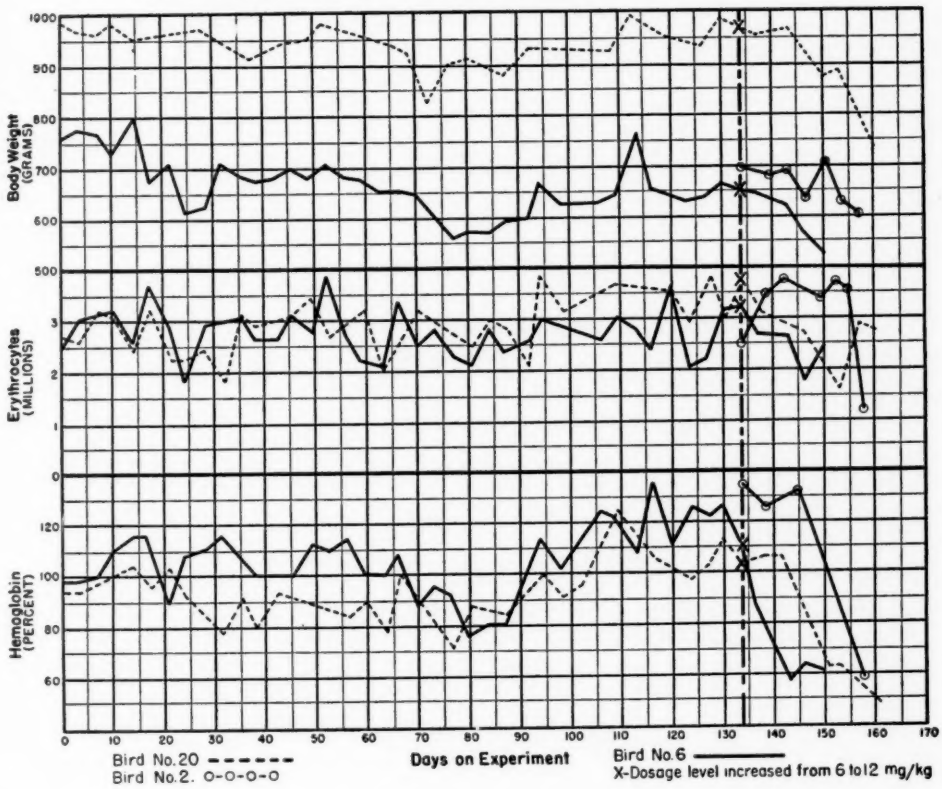
Bird No.		Skeleton Wet Wt. (gm.)	Dry Wt. (gm.)	Pb* Mg. %	Soft Tissue Wet Wt. (gm.)	Dry Wt. (gm.)	Pb* Mg. %	Liver Wet Wt. (gm.)	Dry Wt. (gm.)	Pb* Mg. %	Feathers Wet Wt. (gm.)	Dry Wt. (gm.)	Pb* Mg. %
2	Toxic	71.5	55.8	51.3	—	64.4**	4.41	11.3	2.47	17.81	52.8	52.8	5.09
7	"	78.0**	—	—	—	—	—	10.8	2.52	22.61	55.3	50.0	3.40
4	"	90.2	44.8	65.2	243.5	75.6	4.37	8.2	1.63	11.66	66.1	63.0	3.02
5	"	—	59.2**	64.2	—	74.9**	8.26	12.7	2.51	19.12	74.0	66.0	4.69
62	"	—	68.6**	33.52	449.0	93.7	3.93	10.1	2.95	15.25	71.8	68.0	3.68
18	"	77.0	48.3	32.40	377.1	88.9	6.05	10.8	2.42	25.62	73.7	68.0	2.21
79	"	74.5	60.1	38.76	—	85.8**	6.24	17.4	3.29	17.33	63.4	61.0	4.26
15	"	160.5**	—	—	533.7**	—	—	36.5	6.02	24.58	63.7	61.0	3.67
8	"	149.2**	—	—	227.9**	—	—	9.5	2.01	35.87	64.8	61.0	3.11
19	"	—	55.0**	41.45	—	94.3**	6.69	10.7	3.60	23.89	72.3	70.0	3.00
61	"	—	59.0**	45.42	—	65.7**	11.19	14.5	2.52	24.64	66.0	64.0	2.03
17	"	85.0	52.0	41.45	254.8	61.5	6.88	8.8	1.68	19.64	70.9	65.0	4.46
6	"	78.0	41.8	44.49	231.4	56.4	10.14	8.3	1.82	18.68	53.7	49.0	6.73
20	"	96.6	58.8	57.48	364.4	81.5	10.37	15.2	2.80	24.64	63.5	63.0	6.35
Average		81.8	51.7	46.9	320.0	76.3	7.14	13.20	2.73	20.81	65.1	61.6	3.98
9	Normal	126.5	86.4	3.39	720.0	236.8	1.73	33.5	9.43	0.50	73.0	66.0	1.97
83	"	102.0	63.9	15.15	600.5	192.9	1.02	34.5	8.93	0.56	73.0	61.0	1.31
Average		114.3	75.1	6.77	660.0	215.0	1.38	34.0	9.18	0.53	73.0	63.5	1.64

* Lead content expressed in milligrams per 100 grams dry weight.
** Omitted from average.

TABLE 3.—LEAD METABOLISM AND ERYTHROCYTE COUNT

Bird No.	Dosage Level (Mg./k.g.)	Collection Period	Erythrocytes (Millions)	Pb Ingested (mg.)	Pb Excreted (Mg.)	Pb Excreted %
2	8	1 (7 days)	3.85	27.6	1.4	5.2
		2 (7 days)	2.91	37.6	29.9	79.4
		3 (5 days)	1.20	28.2	12.0	42.6
4	8	1 (7 days)	3.00	52.5	1.4	2.7
		2 (7 days)	2.51	50.2	30.0	59.7
		3 (5 days)	1.45	44.0	28.9	65.6
17	12	1 (7 days)	2.55	79.3	2.2	2.8
		2 (7 days)	2.55	69.0	48.1	69.7
		3 (5 days)	2.21	44.0	35.3	80.2
79	12	1 (7 days)	2.99	69.1	0.95	1.4
		2 (7 days)	1.88	73.0	43.9	60.1

Figure I. Effect of Lead Ingestion on Body Weights, Erythrocytes, and Hemoglobin Level



post-mortem examination. The clinical diagnoses of plumbism were thus confirmed in each instance. Report of part of the gross pathology is desirable for determining the relationship with certain clinical symptoms.

Anemia and emaciation were constant findings with a total absence of any fatty tissues. Noticeable reduction in size of the liver was observed in most birds. The liver of duck No. 15 (Table 2) was the marked exception, with a wet weight of 36.5 g., which is 2.5 g. more than the average weight of liver for normal ducks. The organ was edematous and easily ruptured. That the increase in size was not accounted for by edema alone, is shown in the table of comparative weights of the dry organs, by a weight of 6.02 g. or approximately 2¼ times greater than the average dry weight of livers for all treated birds.

More than the normal amount of a characteristic bright green bile was present in the gall bladder and duodenum of most of the carcasses. Regurgitation of this bile into the gizzard and proventriculus was a common finding.

Necrosis was determined (histologically) to be in part responsible for atrophy of the liver. This was of a diffuse nature and did not produce the sharply defined depressed areas commonly observed in the livers of mammals dying of acute lead poisoning.

Atrophy of the gizzard muscles was regularly observed. Flabby muscle tissue was a general finding in most birds. Marked flabbiness of heart muscle was present in all dosed birds. The prominence of this heart condition was undoubtedly exaggerated by the small volume of impoverished blood.

Clinical Observations:

The type of plumbism induced in these birds did not produce all of the characteristic clinical symptoms commonly seen in mammals. Dark discoloration or hemorrhage of the oral mucosa was not observed in any of the test birds. The first symptom shown was a marked lethargy, with a lessening resistance to being handled and a quick return to a resting position. The symptom of tiring appeared in a few birds following the third or fourth dose of the two higher levels of lead intake. This weakness is interpreted as the beginning of muscle paralysis. Individual variation in the pattern, with paralysis, or wing-drop analagous to wrist-drop in humans, appeared by the end of the sixth day. Marked paralysis of both legs and wings was observed in several birds a day or two prior to death. While present to some degree in most of the birds, paralysis was not a constant finding.

Green bile staining of the feathers in the ventral region was present in most of the birds late in the treatment period, or just prior to death. Changes in the blood with special reference to erythrocytes followed quite consistent patterns. Anisocytosis was observed as early as the third day, and poikilocytosis appeared in several birds on the sixth day.

In the majority of cases, the erythrocyte count dropped during the first 10 or 14 days. In one of the birds (No. 4), the erythrocyte count dropped from 3.03 to 1.03 millions during the first 6 days, but returned to a normal count of 3.07 by the 22nd day. This was followed by a rapid decline in count, and death on the 29th day. Duck No. 18 showed a drop in count of over one million erythrocytes by the 7th day, with return to initial count on the 22nd day. Following this there was a steady decline with a low count of

1.80 millions shortly before death on the 42nd day.

Two birds (Nos. 6 and 20), while receiving 6 mg./kg. for 137 days showed a slight drop in count by the 14th day. Rapid recovery was followed by gains above the initial count, and a normal count on the 137th day. When the dosage for these birds was increased to 12 mg./kg., the red cell pattern changed to that of acute poisoning. Duck No. 6 showed a drop in count from 3.27 to 1.80 within 8 days, and died on the 14th day. The other bird dropped from 3.18 to 1.63 by the 14th day, and died on the 22nd day.

Erratic counts were encountered in some birds a few days prior to death. Sudden return to apparently normal counts and hemoglobin content occurred, apparently due to dehydration resulting from paralysis and inability to take water.

Changes in cell shape included dumbbell, bottle, oat, sickle, and tear-shaped forms. Displacements, and loss of nuclei were not uncommon. Stippling, due to lead poisoning, common in mammalian forms, has not been observed by us in any avian species. Shrinking of red cells was apparent, but typical regular crenation was rare. The percentage of altered red cells was as high as 36% by the 10th day in acutely poisoned birds. Immature red cells showed a pronounced increase by the 8th day. Showers of these poikilocytes regularly occurred as the rate of mature red cell destruction increased.

The change in white cell count showed great variation without consistent pattern of change or shift in type. In general, the count was higher than normal with fluctuations staying within the increased number. These increases in count ranged from a normal initial count of 19,000 up to 90,000, and return to 30,000 within a period of 14 days.

Metabolism Studies: During the initial collection period, which coincided with the first week the birds were on experiment, virtually all of the ingested lead was retained, with the maximum excretion of the element being approximately 5 percent of the intake. In the subsequent periods, the excretion rate was markedly higher.

Chemical Analyses: Although the lead content of tissues of the experimental birds was higher than in the control, the rate of increased deposition was not directly proportional to the dosage level nor to the time the birds were on experiment. The most significant increases in lead content were noted in the livers, where the average value for the poisoned birds was 40 times that for the normal controls. Likewise, the lead content of the skeletons of the pathological birds was appreciably higher (7 times) than that found in the controls.

DISCUSSION

The daily ingestion of 6 mg./kg. of lead in a soluble form produced no untoward condition in 2 mature mallard ducks during a test period of 137 days. Total lead ingested by these birds was 441.2 and 628.0 mg., respectively. These birds had been conditioned and were maintained on a diet of cracked corn and wheat. With this diet, a lead intake of 6 mg./kg. was below that required for the production of toxic symptoms in these experimental birds. However, when the daily lead intake was increased to 12 mg./kg., death due to lead

poisoning resulted in 14 to 22 days, respectively. The long period on the lower intake level apparently had little effect on the rate with which clinical symptoms developed, nor upon the deposition of lead in the various tissues.

The critical lead intake level in these test birds appeared to be between 6 and 8 mg./kg./day. Six ducks receiving the latter amount died of lead poisoning following an average survival period of slightly more than 28 days. The average amount of lead ingested was 158.1 mg., or approximately the weight of a No. 5 shot (165.5 mg). Clinical symptoms of lead poisoning appeared in all birds of this group by the 14th day of the dosing period. Blood changes characteristic of lead poisoning were observed in all birds. An initial stimulation of hemopoesis occurred in one bird (No. 4) prior to the final decline.

Deposition of lead in the tissues showed little variation in amounts between this group and the one which received 12 mg./kg./day. Six birds in the latter group succumbed to lead poisoning following an average survival time of 25 days. All birds in this group showed characteristic clinical symptoms and typical post-mortem lesions of lead poisoning. The average amount of ingested lead was 209.8 mg.

Although the rate of deposition of lead in the tissues was not directly proportional to the dosage rate, it appears that chemical analysis of the liver or skeleton would offer a valuable diagnostic tool for the determination of plumbism in the wild.

CONCLUSIONS

Clinical symptoms diagnostic of lead poisoning in ducks in relation to 2 levels of dosing are herein established.

The critical daily dosage level was found to be between 6 and 8 mg./kg. The average survival time for birds dosed at a level of 12 mg./kg. was 3.5 days less than for birds receiving lead at the 8 mg./kg. level, but there was no significant difference in the deposition of lead in the tissues of the 2 groups.

Lead metabolism studies for 3 consecutive periods showed comparable rates of retention for the 2 dosage levels, with no significant difference in lead retention. The rate of deposition of lead in the tissues, as indicated by metabolism tests, was found to be such that related clinical symptoms could be predicted.

Any one of 3 units, skeleton, liver, or soft tissues might be satisfactory as field samples for the determination of lead poisoning by chemical analysis.

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Accepted for publication July 12, 1950.

A LIST OF MALLOPHAGA FROM GALLINACEOUS BIRDS OF NORTH AMERICA

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During the past few years, the author has made a special study of the Mallophaga found on the gallinaceous birds of North America north of Mexico. The taxonomic papers resulting from that study can be found principally in the Journal of the Kansas Entomological Society.

Since it is seldom that a worker has an opportunity to examine such a wealth of material as was loaned for this study, it is believed that the data should be made available to other workers. Little work has been done on the effect of such external parasites as the Mallophaga on the health and vigor of our game birds. Before such an ecological study is undertaken, the investigator should become familiar with the species of lice which are normally found on the various birds. Contrary to much published literature, the author was unable to find many instances of lice infesting birds which were not considered the normal hosts. The only exception encountered was the presence of *Cuclotogaster heterographus* (Nitzsch), normally found on domestic chickens, on hatchery-reared Ring-necked Pheasants from the California Game Farm, Ontario, Canada, and Ithaca, New York.

All host names are from Ridgway and Friedmann, the Birds of North and Middle America, Part X. I wish to take this opportunity to thank the many individuals and institutions who loaned material for this study.

Bonasa umbellus umbellus (Linnaeus)—Eastern Ruffed Grouse.
Goniodes bonasus Emerson, N. Y.
Lagopoecus umbellus Emerson, N. Y., Penn.

Bonasa umbellus phaia Aldrich and Friedmann—Idaho Ruffed Grouse.
Lagopoecus umbellus Emerson, Idaho.

Bonasa umbellus togata (Linnaeus)—St. Lawrence Ruffed Grouse.
Lagopoecus umbellus Emerson, Ontario.

Bonasa umbellus umbelloides (Douglas)—Gray Ruffed Grouse.
Goniodes bonasus Emerson, Colo., Mont.

Callipepla squamata pallida Brewster—Arizona Scaled Partridge.
Colinicola pallida Emerson, Texas.
Goniodes squamatus Emerson, Texas.
Oxylipeurus callipeplus (Carriker), Texas.

Canachites canadensis canadensis (Linnaeus)—Hudsonian Spruce Partridge.
Goniodes corpulentus Kellogg and Mann, Alaska, Manitoba.
Lagopoecus sp., Alaska.

Canachites canandensis canace (Linnaeus)—Canadian Spruce Partridge.
Goniodes corpulentus Kellogg and Mann, Ontario.

Canachites franklinii (Douglas)—Franklin's Grouse.
Goniodes corpulentus Kellogg and Mann, Mont.
Lagopoecus sp., Mont.

Centrocercus urophasianus (Bonaparte)—Sage Grouse.
Goniodes centrocerci Simon, Idaho, Mont., Ore., Wy.
Lagopoecus gibsoni Hopkins, Idaho, Mont., Ore., Wy.

Colinus virginianus virginianus (Linnaeus)—Eastern Bobwhite.
Colinicola numidianus (Denny), Ga., Ohio, Okla.

Goniodes ortygis Denny, Ala., Ga., Iowa, Md., N. C., Ohio, Okla., S. C.
Menacanthus sp., Okla.
Oxylipeurus clavatus (McGregor), Md., Okla.

Colinus virginianus floridanus (Coues)—Florida Bobwhite.
Colinicola numidianus (Denny), Fla.
Goniodes ortygis Denny, Fla.

Colinus virginianus texanus (Lawrence)—Texas Bobwhite.
Goniodes ortygis Denny, Mont., Ore., Texas, Wash.

Cyrtonyx montezumae mearnsi Nelson—Mearns's Harlequin Quail.
Colinicola mearnsi Emerson, Ariz.
Goniodes submamillatus Emerson, Ariz.
Oxylipeurus montezumae Emerson, Ariz.

Dendragapus obscurus obscurus (Say)—Dusky Grouse.
Goniodes merriamanus Packard, Wy.

Dendragapus obscurus fuliginosus (Ridgway)—Sooty Grouse.
Lagopoecus obscurus Emerson, Calif., Wash., Brit. Col.

Dendragapus obscurus richardsonii (Douglas)—Richardson's Grouse.
Goniodes merriamanus Packard, Mont.
Lagopoecus obscurus Emerson, Mont., Brit. Col.

Lagopus lagopus alascensis Swarth—Alaska Willow Ptarmigan.
Amyrsidea lagopi (Grube), Alaska.
Goniodes lagopi (Linnaeus), Alaska.
Lagopoecus affinis (Children), Alaska.

Lagopus lagopus albus (Gmelin)—Keewatin Willow Ptarmigan.
Amyrsidea lagopi (Grube), N. W. T., P. Q.
Goniodes lagopi (Linnaeus), N. W. T., P. Q., Ont.
Lagopoecus affinis (Children), N. W. T., P. Q., Ont.

Lagopus lagopus alexandrae J. Grinnell—Alexander's Ptarmigan.
Amyrsidea lagopi (Grube), Kodiak Isl.
Goniodes lagopi (Linnaeus), Kodiak Isl.
Lagopoecus affinis (Children), Kodiak Isl.

Lagopus lagopus leucopterus Taverner—Baffin Island Ptarmigan.
Goniodes lagopi (Linnaeus), Baffin Isl.
Lagopoecus affinis (Children), Baffin Isl.

Lagopus leucurus peninsularis Chapman—Kenai White-tailed Ptarmigan.
Goniodes sp., Alaska.
Lagopoecus affinis (Children), Alaska.

Lagopus mutus dixoni J. Grinnell—Dixon's Ptarmigan.
Amyrsidea lagopi (Grube), Alaska.
Goniodes lagopi (Linnaeus), Alaska.
Lagopoecus affinis (Children), Alaska.

Lagopus mutus rupestris (Gmelin)—Rock Ptarmigan.
Amyrsidea lagopi (Grube), N. W. T.
Goniodes lagopi (Linnaeus), Southampton Isl.

Lophortyx californica californica (Shaw)—Valley Quail.
Colinicola docophoroides (Piaget), Calif., Brit. Col.
Goniodes mamillatus Rudow, Calif., Brit. Col.

Lophortyx californica brunnescens Ridgway—California Quail.
Colinicola docophoroides (Piaget), Calif.
Goniodes mamillatus Rudow, Calif.

Lophortyx gambelii gambelii Gambel—Gambel's Quail.
Lagopoecus gambelii Emerson, Ariz.

Meleagris gallopavo silvestris Vieillot—Eastern Turkey.
Chelopistes meleagridis (Linnaeus), Okla., Penn., Va.
Menacanthus stramineum (Nitzsch), Okla., Va.
Oxylipeurus polytrapezius (Burmeister), Mo., Okla., N. C., Texas.

Meleagris gallopavo merriami Nelson—Merriam's Turkey.
Chelopistes meleagridis (Linnaeus), Ariz.
Oxylipeurus polytrapezius (Burmeister), Ariz.

Meleagris gallopavo osceola Scott—Florida Turkey.
Oxylipeurus polytrapezius (Burmeister), Fla.

Oreortyx picta picta (Douglas)—Plumed Mountain Quail.
Goniodes picta Emerson, Calif.
Lagopoecus californicus Kellogg and Chapman, Calif., Nev.

Pedioecetes phasianellus phasianellus (Linnaeus)—Northern Sharp-tailed Grouse.
Goniodes nebraskensis Carriker, Manit., Ont.
Lagopoecus perplexus (Kellogg and Chapman), Ont.

Pedioecetes phasianellus campestris Ridgway—Prairie Sharp-tailed Grouse.
Amyrsidea sp., Wisc.
Goniodes nebraskensis Carriker, Nebr.

Pedioecetes phasianellus columbianus (Ord)—Columbian Sharp-tailed Grouse.
Goniodes nebraskensis Carriker, Mont.
Lagopoecus perplexus (Kellogg and Chapman), Wash.

Pedioecetes phasianellus jamesi Lincoln—Great Plains Sharp-tailed Grouse.
Goniodes nebraskensis Carriker, N. D.

Perdix perdix perdix (Linnaeus)—Hungarian Partridge.
Cuclotogaster heterogrammicus (Nitzsch), Calif., Mont., Wash., Brit. Col.
Goniocotes microthorax (Nitzsch), Mont., Brit. Col.
Goniodes dispar Burmeister, Calif., Mont., Ohio, Va., Wash., Brit. Col., Prince Edwards Isl., Sask.
Menopon pallescens "Nitzsch", Brit. Col., Prince Edwards Isl.

Phasianus colchicus torquatus Gmelin—Ring-necked Pheasant.
Cuclotogaster heterographus (Nitzsch), Calif., N. Y,, Ont.
Goniocotes chrysocephalus Giebel, Mont.
Goniodes colchici Denny, Calif., Iowa, Mont., Ore., Brit. Col., Ont.
Lagopoecus colchicus Emerson, Ill., Mich., Mont., Utah.
Lipeurus maculosus Clay, Conn., N. J., Ore., Wisc., Brit. Col.
Menacanthus sp., Ill., Brit. Col.
Oxylipeurus colchicus Clay, Ill.

Tympanuchus cupido pinnatus (Brewster)—Greater Prairie Hen.
Goniodes cupido Rudow, Nebr., Okla., Canada.
Lagopoecus sp., Okla.

Tympanuchus pallidicinctus (Ridgway)—Lesser Prairie Hen.
Goniodes cupido Rudow, Okla.
Lagopoecus sp., Okla.

Accepted for publication June 13, 1950.

RUFFED GROUSE HATCHING DATES IN WISCONSIN[1]

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Specific hatching dates of ruffed grouse (*Bonasa umbellus*) are seldom found in the literature, despite the importance of nesting phenology to wildlife managers. There are only a very few scattered hatching dates recorded for Wisconsin ruffed grouse. We have tried to fill this gap by compiling a frequency distribution of hatching dates for 69 ruffed grouse broods taken during the late summer of 1949 in northern Wisconsin.

Juvenile ruffed grouse less than 17 weeks old can be aged in weeks from the progress of the postjuvenile molt of primary wing feathers (Bump, *et al.* 1947, pp. 84–90). Thompson and Taber (1948) and Thompson and Kabat (1949) have discussed the use of postjuvenile molts to determine the nesting phenology of several gallinaceous game birds.

[1]This study was made by Wisconsin Pittman-Robertson Project 13-R. Our thanks are due Cyril Kabat, D. R. Thompson and J. J. Hickey for critically examining the manuscript.

The techniques of these authors for dating and Bump's (*op. cit.*) molt progression and egg-laying data were used to construct a reference chart (Table 1) for computing the nesting events of the juvenile ruffed grouse collected for this study. The dates of first egg, first day of incubation, and hatch in Table 1 are based on the assertions by Darrow in Bump, *et al.* (1947, p. 286) that approximately 17 days are required to lay the average-sized clutch of 11 eggs, and that the average incubation period is 24 days. Clutch sizes of Wisconsin ruffed grouse are reported by Grange (1949) and by Schmidt in Leopold (1933) and average slightly more than 11 eggs per clutch.

The hatching dates of all juvenile birds with incomplete wing molts that we examined were interpolated from Table 1. The methods of computation are described in detail by Thompson and Taber (*op. cit.*).

We obtained our brood samples from highway kills and from collections made under state permit with a .22 caliber rifle on back roads and fire lanes in eight northern Wisconsin counties. Nest studies were not undertaken because we consider them too laborious for the information gained.

Collections were made during the 65-day period between July 28, 1949, and the opening of the hunting season on October 1. This period was selected for two reasons. No incomplete wing molts were found among 323 ruffed grouse examined during an October hunting season in 1948, so it was apparent that most northern Wisconsin grouse completed their wing molts before October and would have to be examined in late summer to provide datable nesting information. Secondly, collections were started in July after grouse nesting activities seemed to be completed, so that practically all broods were hatched before samples were collected. Only one young bird was taken from each brood observed, and extreme care was taken to prevent sampling the same brood twice. We therefore assumed that all the grouse we examined were from different broods. We likewise assumed in our collecting that all birds in individual broods molted their primaries at the same rate, as was found true for bobwhite quail (*Colinus virginianus*) by Thompson and Kabat (1950). The grouse population we sampled was thought to be an increasing one that is two or three years from the next peak in numbers.

The terminal period for the collection was indicated by the date on which the first complete postjuvenile wing molt was noted. This occurred September 24, 1949. Sixty-one broods had been sampled by this date. An additional eight broods were sampled during the last week in September, to make a total of 69. Four of the last eight broods had complete wing molts, but were included to take advantage of as many broods as possible and to prevent introduction of bias into the sample. None of the four hatched later than May 30, so they were arbitrarily distributed over the period before May 30 in the proportion in which other broods were represented in the same period.

The weekly distribution of ruffed grouse hatching dates is shown in Table 2. Hatching dates, although assigned to a certain day, were summarized to the nearest week to minimize

TABLE 1.—REFERENCE CHART FOR DATING RUFFED GROUSE NESTING EVENTS

Age*			3 wk	4 wk	5 wk	6 wk	7½ wk	9 wk	10 wk	11 wk	12 wk	14 wk	16 wk	17 wk	Age in days at Hunting Season Opening On		
Primary Condition*			1&2 dr	3 dr	4 dr	5 dr	6 dr	7 dr	¼-¾ gr	8 dr	7 2/3 gr 8 1/3 gr	8 2/3 gr 10 cs	8 4/5 gr 12 cs	All Comp	Sep. 20	Oct. 1	Oct. 15
Date of 1st Egg	1st Day of Incub.	Date of Hatch															
Mar 1	Mar 17	Apr 9	Apr 30	May 7	May 14	May 21	May 31	Jun 11	Jun 18	Jun 25	Jul 2	Jul 16	Jul 30	Aug 6	164	175	189
8	24	16	May 7	14	21	28	Jun 7	18	25	Jul 2	9	23	6	13	157	168	182
15	31	23	14	21	28	Jun 4	14	25	Jul 2	9	16	30	Aug 6	20	150	161	175
22	Apr 7	30	21	28	Jun 4	11	21	Jul 2	9	16	23	6	13	27	143	154	168
29	14	May 7	28	Jun 4	11	18	28	9	16	23	30	13	20	Sep 3	136	147	161
Apr 5	21	14	Jun 4	11	18	25	Jul 5	16	23	30	Aug 6	20	Sep 10	17	129	140	154
12	28	21	11	18	25	Jul 2	12	23	30	Aug 6	13	27	17	24	122	133	147
19	May 5	28	18	25	Jul 2	9	19	30	Aug 6	13	20	Sep 3	10	24	115	126	140
26	12	Jun 4	25	Jul 2	9	16	26	Aug 6	13	20	27	10	17	Oct 1	108	119	133
May 3	19	11	Jul 2	9	16	23	Aug 2	13	20	27	Sep 3	17	Oct 1	8	101	112	126
10	26	18	9	16	23	30	9	20	27	Sep 3	10	24	8	15	94	105	119
17	Jun 2	25	16	23	30	Aug 6	16	27	Sep 3	10	17	Oct 1	15	22	87	98	112
24	9	Jul 2	23	30	Aug 6	13	23	Sep 3	10	17	24	8	22	29	80	91	105
31	16	9	30	Aug 6	13	20	30	10	17	24	Oct 1	15	29	Nov 5	73	84	98
Jun 7	23	16	Aug 6	13	20	27	Sep 6	17	24	Oct 1	8	22	Nov 5	12	66	77	91
14	30	23	13	20	27	Sep 3	13	24	Oct 1	8	15	29	12	19	59	70	84
21	Jul 7	30	20	27	Sep 3	10	20	Oct 1	8	15	22	Nov 5	19	26	52	63	77

*comp.—growth complete. cs—complete secondaries. dr—dropped. gr—grown. wk—weeks of age.

inaccuracies in reading molt stages and to simplify tabulation of data. It is most important to note that 42 broods, or 61 percent, were hatched in the two weeks from May 27 to June 9, while the entire hatching period indicated by our data lasted nine weeks. By June 9, 86 percent of all broods sampled had hatched. July hatches probably occurred, but we believe they were few in number. Thus it appears that an extremely large proportion of the 1949 ruffed grouse reproduction surviving to late summer hatched in a relatively short period. This is consistent with the statement of Darrow in Bump, *et al.* (1947, p. 285) that most hens in a locality begin laying eggs within a few days of each other.

The sharpness of the hatching peak indicates an apparent high success of first nests and lack of renesting. If more renesting had occurred, the peak in hatching would probably not have been as abrupt and would have been spread over a longer time span. However, Darrow in Bump, *et al.* (1947, p. 291) says there is little likelihood of renesting if the first nest is broken up after incubation begins. It is also probable that the spring of 1949, which was warmer and drier than normal (U.S Dept. of Commerce, 1949), made conditions nearly ideal for ground-nesting birds and practically eliminated first-nest failures caused by weather.

The last column in Table 2 shows the approximate age of the various hatching date classes at the opening of the 1949 hunting season. These data indicate that all broods were relatively matured by October 1 and meant good-sized birds in the hunter's bag. Postjuvenile wing molts are complete at 119 days of age (Bump, *et al.* 1947, p. 90). Our field experience has indicated that 16-week-old grouse (112 days) are strong fliers and make excellent shooting. Between 85 and 90 percent of the birds we examined would have been in the latter age group had they lived to the opening of the hunting season.

If our 1949 hatching-date tally adequately reflects ruffed grouse breeding behaviour in a good nesting season, it is interesting to speculate on the annual reproduction in years when such short-term mortality factors as heavy rains

TABLE 2.—WEEKLY DISTRIBUTION OF 69 RUFFED GROUSE HATCHING DATES IN WISCONSIN, 1949

Week	No. of Broods	Approx. Percent	Cumulative Percent	Approx. Age in Days at Opening of Oct. 1 Hunting Season
Apr. 29 – May 5	1	2	2	149
May 6 – May 12	2	3	5	142
May 13 – May 19	7	10	15	135
May 20 – May 26	7	10	25	128
May 27 – June 2	11	16	41	121
June 3 – June 9	31	45	86	114
June 10 – June 16	3	4	90	107
June 17 – June 23	4	6	96	100
June 24 – June 30	3	4	100	93
Total	69	100		

or predation were prevalent during that period in May when most nests are being incubated. If ruffed grouse seldom renest after incubation has started, the number of birds surviving to the fall hunting season could be substantially reduced under such circumstances.

SUMMARY

Hatching dates of 69 broods of ruffed grouse collected during the summer of 1949 in northern Wisconsin were calculated from the stage of postjuvenile wing molt at time of collection. Forty-five of the 69 broods, or 61 percent, hatched in the two weeks between May 27 and June 9. All broods examined hatched in the nine weeks between April 29 and June 30. The sharp hatching peak and relatively short nesting season indicate an apparent high success of first nests and lack of renesting.

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Accepted for publication August 2, 1950

AIR INFLATION AS AN AID IN PELTING MUSKRATS

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[1]The writer is indebted to the following: Frank G. Ashbrook for helpful direction and critical review of the study; Charles M. Mottley for suggestions as to experimental procedure to follow for best statistical evaluation; Mortimer A. McNamara and Sol Robbins of the New York Auction Company for grading the raw pelts; Crosby Frisian Fur Company, Rochester, New York, for careful processing of the pelts so that the metal security fur seals were retained for proper identity; and Cornelius W. Wallace, Refuge Manager, for assistance in securing the desired data and for improving the valve chuck device. Special thanks are due Walter A. Meves of the Branch of Lands of the U. S. Fish and Wildlife Service for his valued assistance in helping with the computations and tabular analyses and for making the accompanying graph.

Air inflation as a means of removing sheep pelts has been used in both Europe and America. In 1934 during the severe drought, sheep on the range of central and western United States died in large numbers. To save the wool compressed air was used to remove the pelts. The possibility of employing such a method to remove quickly and efficiently the pelts of muskrats and other fur animals was investigated in a preliminary way at the Montezuma National Wildlife Refuge in New York. A crude apparatus was devised during the 1946 trapping season and 39 muskrats were pelted with the aid of air

inflation. Compared with 644 pelts handled in the routine manner, 30 or 79.92 per cent of the air-inflated pelts graded "XXX large" while 338 or only 52.48 per cent of the routine pelts graded the same. The annual take of muskrat pelts over a period of years on the Montezuma Refuge has always had a high percentage of "XXX Large" pelts but the increase of 24.46 per cent in this grade as a result of air inflation seemed quite significant. In addition, the trappers observed that air inflation made pelting somewhat easier, the pelts required less fleshing, and a maximum stretch was obtained.

These findings, although only tentative, stimulated further experimentation. Therefore, in order to study the merits and demerits of air inflation as an adjunct to pelting muskrats, an experimental plan was developed and put into operation on the Blackwater National Wildlife Refuge in 1948. It has been pointed out, however, (Dozier, 1945) that muskrats from that refuge, (*Ondatra z. macrodon*), are smaller in size and average 1.3 pounds less than *Ondatra z. zibethicus* of the Montezuma Refuge and are thinner skinned, with comparatively little fat. The purpose was to compare the use of air inflation with the routine method of pelting muskrats to determine: (1) the relative practicability and efficiency of both methods; (2) to ascertain a comparison of size and the possibility of over-stretching; (3) to check the degree of shrinkage caused in the processing of the pelts.

As a first step toward obtaining these objectives, 10 large, 11 medium, and 11 small trapped muskrats were taken at random and inflated with air. Another similar series of 32 muskrats was chosen to be pelted in the routine manner as a control group. Pelting was begun and a record kept of the length of time required by each trapper to remove the pelts of the two groups of muskrats. Recorded time showed that 67.4 seconds were required to pelt each of the 64 air-inflated muskrats and 67.2 seconds for the same number pelted by the routine method. The time required to remove the two groups of 64 pelts each from the carcasses was practically the same but the additional labor required to inflate one group of muskrats is chargeable to the air-inflated pelts.

For statistical analysis and proper interpretation of results it was decided that 120 muskrats be selected for air inflation and an identical number for the routine method of pelting. Random samples were taken. The sexes in each day's catch were determined and the males and females were segregated into groups of (1) subadults, from the early spring brood, weighing 1 lb., 14 ozs. to 2 lbs., 3 ozs.; (2) medium-sized, in their second year, 2 lbs., 4 ozs. to 2 lbs., 10 ozs., and (3) large, in their third year or older, 2 lbs., 12 ozs to 3 lbs., 2 ozs.

EQUIPMENT AND METHODS

An air compressor and a long rubber hose, with a specially devised hand valve and small welding tip attached, were employed in this study. The welding tip was inserted in a small slit, cut on the upper surface of the hind foot, and the air then quickly applied by a slight pressure on the spring valve. An air pressure of about 60 pounds per square inch was sufficient to give the inflated animals an appearance of two to three times normal size.

The inflation progressed in a few seconds from the hind foot up the side and into the fore legs, distending fully the skin around the cheeks and jaws of the head in a grotesque manner and then back down the opposite side to the other hind leg. When the skin of the opposite hind foot was fully distended the operation was completed. If inflation was continued beyond this point, the specimens did not "blow up" but the air soon burst through the nostrils or at some weak point, such as an old scar. As soon as the welding tip was withdrawn, the opening usually immediately sealed itself and the specimen might remain inflated for hours.

In order to make such air-inflation treatment possible for the average trapper, a simple device was also made whereby a bicycle pump could be used in the place of the compressed air equipment. This device consisted of a valve from an old automobile inner tube, with the stem removed and the rubber burnt off, and a small Zenith carburetor jet needle valve screwed in and welded to the same, the end sharpened at a slanting angle. While this method accomplished the same purpose it required more time and considerable manual effort.

Insertion beneath the skin of the hind foot insured the forced air loosening the skin in such a manner that any fat present remained attached to the carcass, enhancing the appearance and marketability of the latter. Meats of the animals skinned by the air-inflation treatment were also a distinctly brighter red, apparently due to aeration, while those by the routine method remained a dark, unattractive red in comparison.

As the animals were weighed a numbered tag was attached and the accompanying data properly recorded. Upon skinning, the pelts were stretched "cased" on standard Maryland wire stretchers, with the tags attached through an eye-hole. Dorsal and ventral outline patterns of each freshly stretched pelt were then made in pencil on heavy manila paper with the number and data recorded on the same. These outline patterns were measured by planimeter, giving the total surface area of each pelt in square inches. Approximately a month later, when the pelts were unquestionably dried, they were removed from the stretchers and similar pattern outlines were made and the pelt areas computed to determine the degree of shrinkage.

The entire 240 experimental pelts were then submitted along with the season's catch from the Blackwater Refuge to a New York auction company for commercial grading and classification. Kellogg (1946) has shown that the majority of the muskrat pelts from this refuge fall in the "Large" size category whereas the majority from the Montezuma Refuge in New York grade "XX Large" and "XXX Large." Dozier, Markley and Llewellyn (1948) have given extensive data on the smaller size and average weight of the Maryland muskrat. In order to insure the identity of the individual pelt being retained, numbered metal tags were attached, usually through a small hole punched through the "snout" which was found to be the best and strongest point for attachment. Arrangements were made with the fur dressers for special care in handling these skins through the tanning and dressing process so that the tags would not be torn loose. In addi-

tion, a series of code punches were made at the "neck" of the pelt to further insure identification. Both systems functioned effectively and only a few tags were torn loose.

DISTRIBUTION BY SIZE OF MUSKRAT PELTS

Percentage distribution by size of 116 air-inflated raw pelts versus 119 skinned by the routine method is given in Table 1, the size grades being based on the "auction grade."

TABLE 1.—PERCENTAGE DISTRIBUTION BY SIZE OF MUSKRAT PELTS (MIXED SEXES).

Size Grade	Routine Method		Inflated Method	
	Number of Pelts	%	Number of Pelts	%
XX Large	16	13.4	15	12.9
X Large	44	37.0	44	37.9
Large	48	40.4	46	39.7
Medium	11	9.2	11	9.5
Totals	119	100.0	116	100.0

A total of 235 pelts was used for this tabulation.

Data presented show that, as far as the rough-grading of the pelts as done at the auction company was concerned, there was practically no difference between the air-inflated or routine method pelts. This is contrary to the wide difference reported by Dozier and Radway (1948) for Montezuma Refuge pelts where results appeared significant in spite of the admittedly unbalanced comparison made between only 39 air-inflated and 644 routine-method pelts.

PELT AREA BY WEIGHT GROUPS AND DEGREE OF SHRINKAGE

After due consideration it was decided that 120 "open" dressed pelts would be sufficient to determine the relative degree of shrinkage involved in the two methods of pelting. In each of the following categories 10 males and 10 females were used: Inflated—Large, Medium, and Small versus Routine-Pelted—Large, Medium, and Small. An additional 10 pelts were also dressed for possible substitution in case of lost identity or excessive machine damage or tearing.

Upon receipt of these pelts from the dressers several months later, individual pattern outlines were obtained by superimposing thin tracing paper over the flattened pelt and using a non-smudging Wolff's carbon drawing pencil. Pelt areas were computed from the outline patterns and planimeter readings and showed the amount of shrinkage that took place during the drying of the skin and the subsequent tanning and dressing process.

In Table 2, data are given on the pelt area means in square inches, correlated with mean body weights according to size groups, and arranged to show the percentage of shrinkage from the freshly stretched skin to the dried pelt and the same after tanning and dressing. In the latter process it should be recognized that the entire decrease in size is not all due to actual shrinkage, but some loss of area may be due to small tears and distortions.

TABLE 2.—PELT AREA OF INFLATED VERSUS ROUTINE MUSKRAT PELTS (MIXED SEXES), ARRANGED IN WEIGHT GROUPS, AND THE PER CENT OF SHRINKAGE.

		Size by weight group	Mean weight Lbs. - Oz.	Square inches of pelt and per cent of shrinkage		
				Freshly Stretched	Dried	Dressed
ROUTINE		Large	3 - 0	169.84	161.60 4.85%	134.25 16.92%
		Medium	2 - 7.2	154.67	148.24 4.16%	119.26 19.55%
		Small	2 - 1.1	139.63	133.74 4.22%	105.52 21.11%
	Mean		2 - 8.3	154.72	147.86 4.43%	119.68 19.06%
INFLATED		Large	3 - 0	170.72	163.61 4.16%	139.30 14.86%
		Medium	2 - 7.3	155.03	149.05 3.86%	121.33 18.6%
		Small	2 - 1.3	137.45	132.64 3.5%	106.24 19.9%
	Mean		2 - 8.4	154.40	148.43 3.87%	122.29 17.61%

120 pelts were used in this table, 20 for each size category in both inflated and routine series.

The tabulation, based on 120 pelts, 20 for each category in both inflated and routine, clearly illustrates that there is less shrinkage with inflated pelts of all size groups and also in the processing from freshly stretched to the dried condition, and from the latter to the dressed product. The average dried, inflated pelt shrank only 17.61 per cent during the tanning and dressing process while the routine method ones decreased 19.06 per cent in area.

Use of the air-inflation method resulted in an average of 2.61 square inches more pelt per animal or an increase of 1.45 per cent.

PELT AREA IN RELATION TO BODY WEIGHT OF MUSKRATS

Pelt area in relation to body weight of animals, skinned by the air-inflation treatment versus the routine method, is shown graphically in Figure 1. By using mean curves a truer picture and a better understanding of the facts is had. The inflated series, both dried and dressed pelts, averaged larger than those obtained by the routine method. The largest dressed experimental inflated skin, that of a 3 lbs. 5 ozs. animal, contained 150.15 square inches of surface area; the largest routine pelt, from a 3 lbs. 6 ozs. animal, only 141.95 square inches. This difference in pelt surface area was apparently not great enough to alter the auction company size gradings.

SUMMARY

During the 1948 trapping season at the Blackwater National Wildlife Refuge near Cambridge, Maryland, further studies were undertaken to determine the relative merits and demerits of the

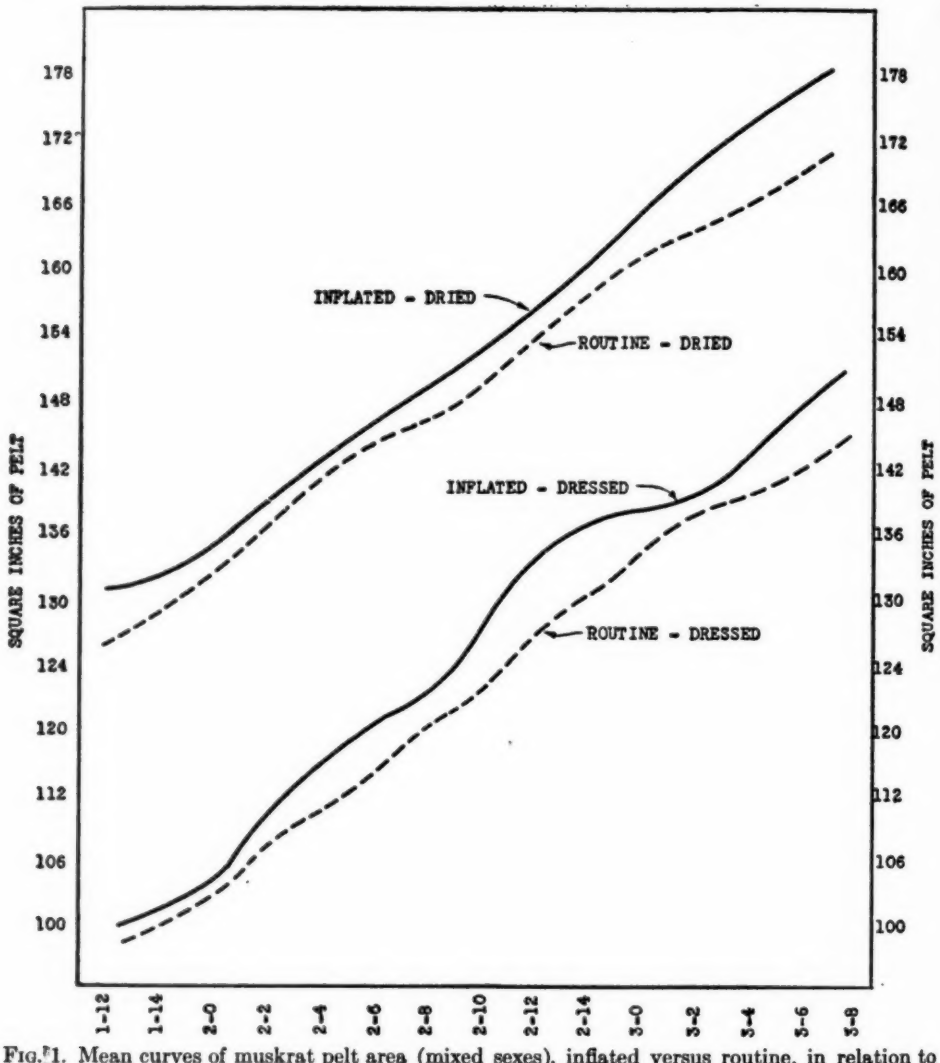

FIG. 1. Mean curves of muskrat pelt area (mixed sexes), inflated versus routine, in relation to body weight of animal.

compressed air inflation method of pelting muskrats. It is obvious that this method is not practical for individual trappers on extensive coastal marsh tracts, such as in southern Louisiana, where there is little or no demand for the carcasses and the animals are for the most part pelted in the marsh and only the skins are brought out. Differences in skin thickness and amount of accumulated fat present on muskrats from various sections of the country also influence pelting operations and would undoubtedly have an important bearing on methods employed. The comparatively thin skin and almost total lack of fat on the Blackwater Refuge muskrats as compared with the ex-

tremely fatty condition of those from the Montezuma Refuge in central New York could largely account for the marked differences in results obtained at the two widely separated locations.

1. Although various skinners found that the air-inflation treatment made the skinning noticeably easier, a practical time test with two operators, each skinning 32 air-inflated and 32 routine pelted animals, demonstrated that, as far as actual time required for skinning Maryland muskrats is concerned, there was little or no difference between the two methods. Further, the time expended in actual inflation of the animal must also be included.

2. Both local fur dealers and New York auction company officials who graded and examined the air-inflated pelts, in the raw and freshly stretched condition and also fully dried, discounted any possibility of serious overstretching or pulling apart of the skins used. The high quality of the dressed pelts also upheld this conclusion.

3. A percentage distribution by size study of pelts of both methods surprisingly showed that, as far as the rough grading into size groups as done at the auction company of these experimental Maryland pelts was concerned, there was practically no difference in results of the two methods.

4. Less shrinkage took place with the inflated pelts of all size groups in processing from freshly stretched to the dried condition and from the latter to the dressed product than with the routine method pelts. There was 1.27 per cent less shrinkage in the tanning and dressing of the inflated pelts than with those by the routine method (17.82% for the inflated, 19.09% for the routine).

5. The air-inflated series, both dried and dressed pelts, averaged slightly larger than those obtained by the routine method. Computed pelt surface areas of 60 air-inflated and 60 routine pelted, in relation to body size and weight, proved the average dressed, inflated pelt to be 2.61 square inches, or 1.45 per cent larger, than the routine. If pelts were purchased on the basis of actual surface area rather than on rough grading, the air-inflation treatment would unquestionably prove worthwhile.

6. The present study with Maryland muskrat pelts shows, however, that further use of the air inflation treatment is not warranted inasmuch as it did not result in appreciably faster skinning, larger pelt grades, or a greater financial return.

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Accepted for publication Aug. 9, 1950.

SOME DYNAMICS OF A MULE DEER POPULATION

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Censusing a deer herd each year and classifying it as to sex and age will, if carefully analyzed, reveal interesting information on actual population behaviors.

Censuses have been made of the Interstate Deer Herd each year on its winter range, starting in 1943. This herd summers in southern Oregon and winters at lower elevations adjoining in northern California. The censuses were made in connection with a study of an irruption of the herd and depletion of its winter range. The work for the period 1944 to 1947 is herein analyzed on the basis of reproduction and computed losses.

The problem was reported on originally by Fischer and others of the U. S. Forest Service (1944) and subsequently by the Interstate Deer Herd Committee (1946, 1947, 1949 and 1950) comprised of representatives of the California Division of Fish & Game, the Oregon Game Commission and forest officers of Region V (California) and VI (Pacific Northwest).

The census method was described by Cronemiller and Fischer (1946) and has been checked by several methods. The comparisons are shown in the report of the committee for 1947.

Up until February 1 of each year, few antlers had been dropped and census workers classified animals as to sex. They also segregated them into fawns and adults.

Repeating the census and classification work gave the numbers of young deer that came into the herd and yielded an opportunity to compute the disappearance or loss of deer. The legal kill is only roughly estimated, there being at the time no reports required of successful hunters. In comparison with herds where the kill ratio is known the kill shown appears to be over-estimated. The remainder of the disappearance could be assumed to represent all other losses. These include a small poaching loss, unrecovered hunter kills, predation by coyotes, and occasional winter killing induced by deep snow or from a prolonged muddy condition in early spring. The bulk of the loss is in the unexplainable "natural" category involving malnutrition abetted by adverse weather and supplemented by external and internal parasites and by pulmonary ailments.

Table 1 shows the female population as of January 1, 1944, 1945, 1946 and the remaining number of adults in 1947. The total number of fawns each year was assumed to be represented by equal numbers of males and females.

Of the 2,538 fawns on January 1, 1944, those alive a year later fell in the adult classification. Of the total number of 15,914 females in 1944, only 9,900 does remained a year later. This indicated a loss or disappearance of 6,014 animals. During 1944, a net of 3,300 female fawns appeared but the following year a total of 4,985 does had been lost. Similarly in 1947 the data shows a

TABLE 1.—CHANGES IN FEMALE POPULATION FROM JAN. 1, '44 TO JAN. 1, '47

	1944	1945	1946	1947
Fawns	2538	3300	2257	
Adults	13376	9900	8215	7008
Total	15914	13200	10472	
Loss	6014	4985	3464	

loss of 3,464 does. Of the total loss only 500 were taken by hunters. This was in 1945 when a special hunt was authorized by the Oregon Game Commission. Otherwise, only bucks could be legally taken. Spike bucks are fully protected in Oregon. In California forked horn deer in this herd are also protected.

Table 2 shows the accretions and disappearance in the buck population. The loss was 2,646, 3,900 and 2,011 for the various years. This is separated into the legal hunter take and the balance which is assumed to represent other losses.

Hunter success varies greatly from year to year. Most of the take is in Oregon and a good part of it while the deer are in migration. If the weather is warm during the hunting season movement is slow, if any, and the kill is light. With cold weather and storms movement is rapid and the take heavy. As a result, the male population does not show as consistent a trend as the female. Doe numbers have been consistently downward indicating the peak of the irruption has passed and that the herd size is returning to a balance with its habitat capacity. Table 3 recapitulates the loss of deer.

Of the total disappearance of 23,001 animals only 4200 were taken by hunters. During the period the number of adults was reduced by 6,800 animals. Had the herd remained static it can be assumed there would have been a

TABLE 2.—CHANGES IN MALE POPULATION FROM JAN. 1, '44 TO JAN. 1, '47

	1944	1945	1946	1947
Fawns	2538	3330	2257	
Adults	1548	1440	870	1115
Total	4086	4770	3127	
Loss	2646	3900	2012	
Hunters	1200	1500	1000	
Other	1426	2400	1012	
Total	2626	3900	2012	

TABLE 3.—COMPUTED LOSSES OVER 3-YEAR PERIOD FROM JAN. 1, '44 TO JAN. 1, '47

	Bucks	Does	Total
Hunter Losses	3700	500	4200
Other Losses	4838	13963	18801
Total	8538	14463	23001

natural loss of at least 12,000 animals and that those taken by hunters would have represented less than one-fourth of the total disappearance. Actually in this herd it represented only 17%.

There is evidently a still greater loss between pregnancy and the winter count of fawns. Chattin (1948) found 1.7 embryos per doe in 50 animals taken on this area during the winter for study. (This is slightly above the 1.6 average of reports from western states.) However, the winter counts averaged 0.51 fawns per doe indicating a disappearance of over 37,000 additional potential animals in the three year period. This would indicate a hunter harvest of less than 7% of potential.

CONCLUSIONS

Recognizing the limitations of the census methods, there are, of course, errors in all of the data. The writer believes that these rarely exceed 25% and are probably considerably less. However, accepting that there are gross errors in the data, it still can be concluded:

1. The breeding potential in mule deer is high; 170 fawns per 100 adult does being observed.
2. The hunter harvest is a very small fraction of the potential.
3. That computations such as those presented point to the fact there are great opportunities for management:
   - A. In improving survival from pregnancy through birth and growth of young.
   - B. In directing all forms of land management towards habitat improvement and particularly towards improving nutrition.
   - C. In harvesting the herds with a view towards keeping numbers within the capacity of the habitat, thereby raising nutrition levels and improving natural survival.

   These points are borne out by correlated forage studies which clearly indicate serious range deterioration and that the important forage plants are overused by at least 30%.
4. That additional studies are needed to evaluate the indicated losses in order to guide management measures.

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Accepted for publication August 17, 1950.

FOOD HABITS OF THE BOBCAT IN THE NEW ENGLAND STATES

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Thousands of dollars are spent yearly by various New England states to control the bobcat (*Lynx rufus*) without an adequate knowledge of its ecology. Besides causing expenditure of bounty money, the bobcat is of considerable economic importance. This furbearer is a much sought prize by sportsmen. Also, it is of basic significance to learn the extent of this mammal's predation on small injurious mammals and game species.

Hamilton and Hunter (1939), Marston (1942), and others have studied the food habits of the bobcat in the New England states. These investigations found mice, hares, rabbits, deer, squirrels, and porcupines to be the important food items in the bobcat's diet.

Materials and Methods:

In order to secure a sufficient number of specimens for a food study, contacts were made with bobcat hunters and trappers in Massachusetts, New York, New Hampshire, and Maine. Other contacts were made with conservation departments, conservation officers, taxidermists, and fur dealers.

Since the New Hampshire Conservation Department requires the surrender of bobcat carcasses to conservation officers before payment of bounties, 111 carcasses and stomachs were received from this state. Material from other states was collected as follows: Massachusetts, 81; Maine, 17; New York, 14; and one from Vermont.

After the carcasses were weighed and measured, the stomach contents and fecal matter from the large intestines were removed and examined. Since the stomach contents and fecal matter often contained different food items, contents of the large intestine gave a clue to the food when the stomach was empty. If the same item was found in both the stomach and large intestine, it was recorded as one occurrence, although it may have represented two meals. It was felt that combining the frequency index figures for fecal matter and stomach contents would give a better clue to the bobcat's diet. Those stomachs that contained only a few vibrissae, fur, and debris in trapped cats were considered empty. Of 224 stomachs received, 61 were empty. Fecal matter was collected from the large intestines of 132 carcasses. When animals known to have been trapped were received, the trapper was contacted and the bait determined. If the bait was in the stomach or intestine, it was not recorded. Calculation of bulk frequency was confined to stomach analysis. Since in many instances the date of consumption for food items represented in scats is problematical, the results are discussed separately. Of 250 bobcat scats collected in Massachusetts, 150 were collected inside the fenced Quabbin Reservoir. This reser-

voir covers approximately 100 square miles of land and is not subject to hunting. It has a high population of deer and small game mammals.

Of the 224 stomachs and carcasses received, two were collected in October, 11 in November, 61 in December, 44 in January, 44 in February, 50 in March, two in April, and one in May. Seven stomachs from Maine are without dates.

Bobcat scats are frequently confused with those of foxes. They may best be distinguished by their large size, site of disposal, lack of fruit, seeds, or insects, and frequently by their shape. Generally bobcat scats are larger than those of foxes. The sites of fecal disposal for cats are dirt roads, on or against rocks, and occasionally on anthills. Difficulty in identification arises when there is no snow but those scats evacuated on dirt roads usually can be identified by finding the cat scratchings. Occasionally the bobcat will eat some vegetation, but this is probably accidental.

DISCUSSION OF FOOD ITEMS

Varying Hare (*Lepus americanus*): Remains of varying hare were found in 38.0 per cent of the stomachs and intestines (Table 1). Hare remains occurred in 19.6 per cent of 250 scats examined (Table 2). This leporid is one of the staple food items of the bobcat in New England.

Several experienced bobcat hunters and trappers in Massachusetts stated that they have never seen evidence indicating that a cat has killed a varying hare. From this statement and the analysis of the food habits of the bobcat in Massachusetts, it appears that the bobcat prefers the cottontail rabbit to the varying hare.

TABLE 1.—FREQUENCY OF OCCURRENCE IN PERCENTAGE OF FOOD ITEMS CONTAINED IN THE STOMACHS OR LARGE INTESTINES OF 208 BOBCATS FROM NEW ENGLAND AND NEW YORK COLLECTED DURING THE FALL AND WINTER MONTHS (10/48 – 3/49). PERCENTAGE TAKEN TO NEAREST DECIMAL PLACE.

Food item	Percent Frequency of Occurrence
Varying hare	38.0
Deer	32.2
Cottontail rabbit	22.1
Porcupine	18.3
Field mouse	9.6
Gray squirrel	8.2
Unidentified bird	2.4
Carrion (Domestic mammal)	2.4
Red squirrel	1.9
Flying squirrel	1.4
Ruffed grouse	1.4
Deer mouse	0.5
Red-backed mouse	0.5
Chipmunk	0.5
Muskrat	0.5
Short-tailed shrew	0.5
Chicken	0.5
Crow	0.5
Slate-colored junco	0.5
House cat	0.5

TABLE 2.—ANALYSES OF 250 SCATS COLLECTED FROM VARIOUS SECTIONS OF MASSACHUSETTS. PERCENTAGES CARRIED TO NEAREST DECIMAL.

Food Item	Percent Frequency of Occurrence
Cottontail rabbit	32.4
Deer	28.0
Varying hare	19.6
Field mouse	14.4
Porcupine	6.8
Gray squirrel	6.8
Red squirrel	2.4
Flying squirrel	2.0
Woodchuck	2.0
Grouse	2.0
Muskrat	1.6
House cat	1.6
Flicker	1.6

Deer (*Odocoileus virginianus*): Remains of deer occurred in 32.2 per cent of the stomachs and intestines (Table 1). This is a higher percentage than reported by other investigators. Such a high frequency of occurrence in the bobcat's diet is probably indirectly due

to the lack of tracking snow during the open deer season in the New England area in 1948. Presumably wounded deer provide a large share of the food. The stomach of a 32 pound male cat killed in April, 1949, in the Quabbin Reservation area near Amherst, Massachusetts, contained over three pounds of deer flesh including remains of a foetal deer. Deer occurred in 34.7 per cent of 150 scats collected in this reservation. Cat feces containing deer remains are usually larger and more conspicuous to the eye, and therefore may comprise more than their proportionate share of the scats collected.

Four Massachusetts deer reported to be killed by bobcats were examined. In all but one, the deer had apparently died from gunshot wounds. Fang marks in the neck of a young doe suggested that the cat had killed it. In this case the animal had a badly crippled front leg, the result of an old gunshot wound. Interviews with hunters and trappers in Massachusetts showed that no positive deer kills have been observed. Many of the observers state that they have found where bobcats have fed on deer carrion every year "directly after the open deer season." This statement is corroborated by the dates of occurrence of deer in the stomachs of Massachusetts and New Hampshire bobcats.

Field observations showed that bobcats will often follow deer trails for short distances in snow. Bobcat tracks were observed after a snowfall following trails made by animals and man. Ploughed roads were frequently used.

J. W. Scott, conservation officer at Guild, New Hampshire, states that 23 deer were found killed by bobcats during the winter of 1947 in the Corbin Park area in the central part of the state. He believes this high mortality was due to the deep snow. It should be noted that the deer population in this fenced-in reserve is reportedly high. P. T. Doherty, conservation officer of Wilton, New Hampshire, reports that in the winter of 1947 during a period of deep snow, two wardens working the Bear Brook State Park and Reservation in New Hampshire, found three freshly killed deer. Upon skinning out the deer, they discovered all three cases had toothmarks on the back of the neck and no wounds on the carcasses.

To judge by the deer carcasses observed in this study, bobcats prefer to feed on the abdominal and flank region. Apparently the cats leave little meat upon finding a deer carcass. Marston (1942) states in Maine that cats waste considerable meat.

Cottontail rabbit (*Sylvilagus floridanus*): Remains of cottontail rabbit were found in 22.1 per cent of the total number of stomachs and intestines examined (Table 1). Of the bobcat kills recorded in the field in Massachusetts the cottontail rabbit was the most common victim. D. T. Ford, experienced bobcat hunter and trapper, on January 1, 1949, observed evidence at Leverett Station, Massachusetts, indicating that a bobcat had killed five cottontail rabbits and one partridge. All kills were found buried or covered by snow and leaves in a low-bush blueberry patch. These kills were made all in one day or night judging by the fresh cat tracks in the snow. This suggests that the bobcat may kill more than it eats, a habit which should be recognized in evaluation of the results of food habit studies.

The analysis of 58 stomachs from Massachusetts bobcats showed cottontail rabbit as the chief food item, comprising 32.8 per cent of the total occurrences. Cottontail in Massachusetts occurred in 32.4 per cent of the 250 feces (Table 2). In comparison, the cottontail rabbit was found in only five stomachs of 76 analyzed from New Hampshire, probably reflecting low availability.

Porcupine (*Erethizon dorsatum*): Remains of porcupine were found in 18.3 per cent of the total material examined (Table 1). The quills of porcupine were recorded in 31 out of 172 carcasses examined. A large male cat received from the New Hampshire Conservation Department has been found paralyzed in its hind quarters, a condition arising from the entry of bird shot into the spinal column. It is noteworthy that porcupine quills were present on the inside of both front legs, in its face and chest; and porcupine remains were found in its stomach. Apparently in spite of its disability this cat had successfully killed a porcupine. Other carcasses showed quills penetrating the stomach wall and duodenum, without any apparent harmful effects. Porcupine quills were most frequently found on the inside of the front legs, in the paws, face, mouth, chest, and top of head.

Porcupine was found in 6.0 per cent of 150 scats from the Quabbin Reservoir area where many other bobcat prey species are abundant. This suggests that porcupine is an important food item in the bobcat's diet. Many New Hampshire and Maine conservation officers report finding porcupine kills.

Field mice (*Microtus*): Remains of field mice were found in 9.6 per cent of the total material analyzed. Scat analysis of 250 feces from Massachusetts revealed field mice occurring in 14.4 per cent. These rodents are usually bolted entire by the cats. Hamilton and Hunter (1939) suggest that such a high percentage indicates the cats may spend considerable time hunting mice.

Gray squirrel (*Sciurus carolinensis*): Remains of gray squirrel were found in 17 of the 208 stomachs and intestines examined. The entire carcass of this rodent is usually devoured by the cat. Scat analysis of 250 feces of Massachusetts cats showed the gray squirrel to occur in 6.8 per cent.

Unidentified birds: Remains of birds were found in five of 208 stomachs and intestines.

Carrion: Remains of domestic mammals were found in five of the 208 stomachs and intestines examined, suggesting that the cats fed on such carrion as dead cattle and horses.

Red squirrel (*Sciurus hudsonicus*): Remains of red squirrel were found in four of the 208 stomachs and intestines examined. Six of 250 bobcat scats collected in Massachusetts contained red squirrel remains.

Flying squirrel (*Glaucomys volans*): Remains of this animal were found in three of the 208 stomachs and intestines. Flying squirrel remains occurred in two per cent of the 250 feces collected in Massachusetts.

Ruffed grouse (*Bonasa umbellus*): Remains of grouse were found in 1.4 per cent of the total material analyzed. This low frequency of occurrence suggests that the grouse is not an important food item of the bobcat in the New England States. Analysis of 150 scats from the Quabbin Reservation in Massa-

chusetts, with a high grouse population, showed grouse occurring three times.

Miscellaneous food items: The deer mouse (*Peromyscus maniculatus* or *leucopus*), red-backed mouse (*Clethrionomys gapperi*), chipmunk (*Tamias striatus*), house cat (*Felis catus*), short-tail shrew (*Blarina brevicauda*), crow (*Corvus brachyrhynchos*), muskrat (*Ondatra zibethica*), slate-colored junco (*Junco hyemalis*), and chicken all occurred once in the examination of stomachs and intestines. Muskrat, house cat, and flicker (*Colaptes auratus*) each occurred once in the examination of 250 scats from Massachusetts.

Three scats collected on a dirt road in Massachusetts on April 8, 1949, revealed the following food items: varying hare (pelage and teeth) red squirrel (pelage and feet), flicker (bill and feathers), and house cat (carpels and claws). The freshness and position of these scats give evidence they were deposited at the same time by the same cat.

ACKNOWLEDGEMENTS

Thanks are expressed to the Massachusetts Cooperative Wildlife Research Unit and its cooperating agencies (U. S. Fish and Wildlife Service, Massachusetts Division of Fisheries and Game, University of Massachusetts and the Wildlife Management Institute) for financial support, and to Dr. W. J. Hamilton, Jr., Department of Conservation, Cornell University, Ithaca, New York, and Dr. William G. Sheldon, Leader, Massachusetts Cooperative Wildlife Research Unit, University of Massachusetts, Amherst, Massachusetts, for their assistance and advice in this study.

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Accepted for publication September 5, 1950.

EFFECTS OF FIVE-YEAR DDT APPLICATION ON BREEDING BIRD POPULATION

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On June 5, 1945, a 117-acre tract of bottomland forest on the Patuxent Research Refuge was sprayed with a single aerial application of DDT in oil at the rate of 2 pounds per acre to determine, among other things, the effect on the breeding bird population. By taking frequent censuses before and after spraying, in two check areas as well as in a 31-acre plot at the center of the treated area, it was found that a single application of 2 pounds of DDT per acre had no apparent effect on the breeding birds of that mature forest habitat, save possibly for the American redstart. A detailed report of the results of the 1945 investigations has been published by Stewart, *et al.* (Journ.

Wildl. Mgt. **10** (3): 195–201, 1946).

In order to determine whether continued yearly sprayings have any detrimental effect on nesting birds, the area was treated again on June 8, 1946 at the rate of 1.1 pound per acre. Breeding bird censuses were conducted before and after the spraying. Subsequent applications at the rate of 2 pounds per acre were made on May 21, 1947, June 3, 1948, and June 1, 1949, and breeding bird censuses were again made in 1949. The methods employed in all years were the same as those described in the above-mentioned publication.

Table 1 shows the bird populations (converted to pairs per 100 acres) of the 31-acre study plot for the years 1945, 1946, and 1949, together with the changes in population as represented by the differences between the 1945 and 1949 figures. For comparison, the population changes in an unsprayed area of 32 acres (converted to pairs per 100 acres) are tabulated in the last three columns. A plus sign (+) indicates that less than one-half of a territory was present within the study area.

The ruby-throated hummingbird decreased from 23 pairs per hundred acres in the sprayed area in 1945 to no pairs in 1946, suggesting the possibility that the DDT had a detrimental effect on this species. In 1949, however the population had risen to 13 pairs per hundred acres, which is the same density recorded in the check area in both 1945 and 1949.

The three commonest breeding species,

TABLE 1.—POPULATION CHANGES (pairs per 100 acres) IN SPRAYED AND CHECK AREAS DURING 5-YEAR PERIOD.

	Sprayed Area				Check Area		
Species	1945	1946	1949	Change	1945	1949	Change
Wood duck	3	3	+	−3	0	+	0
Red-shouldered hawk	0	3	+	0	0	+	0
Yellow-billed cuckoo	0	10	3	+3	5	3	−2
Ruby-throated hummingbird	23	0	13	−10	13	13	0
Pileated woodpecker	0	0	2	+2	+	3	+3
Red-bellied woodpecker	6	10	8	+2	9	8	−1
Hairy woodpecker	3	3	3	0	2	5	+3
Downy woodpecker	10	10	13	+3	6	8	+2
Crested flycatcher					3	0	−3
Acadian flycatcher	45	48	58	+13	36	53	+17
Blue jay	3	0	+	−3	7	3	−4
Carolina chickadee	5	6	11	+6	7	5	−2
Tufted titmouse	16	16	10	−6	15	8	−7
Carolina wren	6	6	0	−6	3	3	0
Wood thrush	10	10	3	−7	31	8	−23
Blue-gray gnatcatcher					2	0	−2
Yellow-throated vireo	3	6	3	0	2	3	+1
Red-eyed vireo	94	87	68	−26	100	91	−9
Parula warbler	65	45	39	−26	44	47	+3
Oven-bird	+	0	0	0	1	0	−1
Louisiana water-thrush	6	6	2	−4	+	0	0
Kentucky warbler	23	19	15	−8	22	20	−2
Yellow-throat					0	16	+16
Hooded warbler	+	0	0	0	2	5	+3
American redstart	58	45	32	−26	34	47	+13
Scarlet tanager	26	21	18	−8	18	19	+1
Cardinal	10	10	6	−4	9	9	0
Total	415	366	307	−108	371	377	+6

red-eyed vireo, parula warbler, and American redstart all showed decreases of 26 pairs per hundred acres in the sprayed area, but showed no corresponding decrease in the check area. It is significant that all three of these species are largely treetop feeders and that they are entirely insectivorous. It is also significant that each showed an initial decrease in 1946, and that each decreased still further by 1949. The total decline in the population of all species in the treated area over the four-year period 1945–1949 was 26 percent, compared to an increase of 1.6 percent in the check area. Seventy-two percent of the total decrease can be attributed to the three species just considered.

Although the four-year cumulative effect of the DDT spraying appears to have affected the red-eyed vireo, the parula warbler, and the American redstart, only the latter species showed a significant decline immediately following each application. Table 2 depicts the percentage change in each of the twelve commonest species as determined from the number of abandoned territories after each spraying. In order to take advantage of all available data, these figures are based upon all pairs under observation, including some just outside the boundaries of the study plots.

The 100 percent increase in the ruby-throated hummingbird in the sprayed area immediately after the date of spraying in 1949 and the large percentage decrease in the check area have no significance. These changes are based on very small samples (2 and 4 pairs, respectively), and since the hummingbird is one of the most difficult species to census, the apparent increases or decreases may have resulted in part from inadequacies of the census method. The figures are included in this table to emphasize the fact that no significant decrease in hummingbirds took place in the sprayed area in the days immediately following the application of DDT. Although the red-eyed vireo and the parula warbler show fairly constant slight decreases, these are not significantly greater than those in the check area. The scarlet tanager popu-

TABLE 2.—PERCENTAGE CHANGES IN POPULATION OF COMMONEST SPECIES WITHIN 10-DAY PERIOD FOLLOWING SPRAYING.

	Sprayed Area				Check Area
Species	1945	1946	1949	Ave.	Ave. (1945 & 1949)
Ruby-throated hummingbird	−14		+100	+	−50
Red-bellied woodpecker	−25	0	0	−8	0
Downy woodpecker	0	0	0	0	0
Acadian flycatcher	0	−6	0	−2	−8
Tufted titmouse	0	0	0	0	0
Wood thrush	0	0	0	0	0
Red-eyed vireo	−11	−3	0	−5	−3
Parula warbler	−4	−7	−8	−6	−6
Kentucky warbler	0	0	0	0	−11
American redstart	−32	−20	−17	−23	−6
Scarlet tanager	−8	−13	−14	−12	−17
Cardinal	0	0	0	0	0

lation declined after spraying each year, but the average change was less than that noted in the check area and presumably was due to cessation of singing, completion of nesting, or some other seasonal factor.

The redstart was the only species which showed a significant decline each year, decreasing from 17 to 32 percent and with an average decrease of 23 percent in the sprayed area. The average decline in the check area was only 6 percent.

In 1945 the decrease of 32 percent in the redstart population was further substantiated by the finding of a poisoned adult, and by the desertion of a nest with four half-grown birds. Evidence accumulated in the succeeding four years backs up the original conclusion that the redstart is the species most seriously affected.

SUMMARY

Aerial applications of DDT in oil at the rate of 2 pounds per acre applied over a four-year interval on bottomland forest resulted in a 26 percent decrease in the breeding bird population by the fifth spring. The American redstart, parula warbler, and red-eyed vireo suffered decreases of 44 percent, 40 percent, and 28 percent, respectively, over the four-year period. Only the redstart decreased significantly immediately following application of the spray; a few days after the first, second, and fifth annual sprayings an average of 23 percent of redstart territories were deserted. No significant decrease was observed for other species, either immediately following spraying, or over the four-year period.

Accepted for publication September 7, 1950.

DISEASE IN RELATION TO WINTER MORTALITY OF DEER IN NEW YORK[1]

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INTRODUCTION

The material presented here is part of a summary report of a comparative disease investigation conducted in New York during the years 1939 through 1943. Among the disease problems pertaining to deer, there was one which involved an investigation to determine what role was played by certain parasites found in those animals which had succumbed to rigorous winter conditions, occurring especially in the central part of the Adirondack Mountain area. Although malnutrition appeared as the chief predisposing factor to deer mortality, the animals often were found with an adequate volume of food in their stomachs, and the quality of that food was, in an occasional

[1]Contribution from Pittman-Robertson Project 35-R, New York State Conservation Department, Wildlife Research Laboratory, Delmar, New York. (Presented at 1950 meeting, American Society of Mammalogists, Mammoth Hot Springs, Yellowstone National Park).

instance, satisfactory judging from what is known of the comparative value to deer of many browse species.

These findings suggested that factors other than simple inanition might be contributing to winter losses of deer and that parasitic disease was possibly one. Accordingly, plans were made to examine as many victims of winter mortality as possible, and to collect survivors for comparative work. For the most part, the 256 specimens studied were taken along the south branch of Moose River in Hamilton County, the DeBar Mountain Game Management area and the William Rockefeller estate at Bay Pond in Franklin County.

FINDINGS

Appearance at Autopsy. Nearly every deer found dead or dying was extremely emaciated. The few exceptions, where cause of death was not attributable to shooting or other mechanical injury, contained some fat in the mesenteries and emaciation had not progressed to an extreme stage before death. The lungs frequently showed areas of congestion suggesting pneumonia, and in some instances these possessed a dark red, liver-like consistency (*red hepatization*). The livers of adult animals were frequently and severely infested by liver flukes (*Fascioloides magna*). Occasionally the spleen was enlarged but usually this organ was somewhat atrophic. Vessels of the heart sac (*pericardium*) were frequently congested but no gross evidence of bacterial pericarditis or involvement of the heart muscle was present. Congealed blood in the heart and aorta occasionally presented an abnormally pale appearance suggesting anemia. Kidneys were grossly normal. The rumina were usually from half to three-quarters full of such browse species as spruce and balsam, miscellaneous dead twigs and leaves and soil. Areas of erosion with hemorrhage were usually found in the glandular lining of the abomasum. These were not associated with parasites and were interpreted as evidence of autolysis probably due to lowered resistance of the stomach lining to its own digestive juices. The intestinal tracts usually appeared normally full of food.

Relation of Parasites to Winter Mortality. Lungworms, liver flukes and nose bots appeared to be the most likely parasites for more intensive observation in relation to winter mortality. Of these, the deer lungworm (*Leptostrongylus alpenae*) and liver flukes appeared to be the most damaging. A comparison of the incidence of parasites in winter-kill deer with their incidence in deer collected within the same region is presented in Table 1. All four species of parasites have a higher incidence in winter-kill animals of both age classes excepting incidence of liver flukes in fawns. Incidence of liver flukes in adult, winter-kill deer is nearly double that in those collected, and the difference is significant by the Chi-square test.

Infestations by liver flukes were frequently heavy, and much destruction of liver tissue had resulted. Although the writer has seen an estimated third of the liver destroyed in an otherwise normal, healthy appearing animal, it is possible that in winter hardship and general inanition, the physiological effects of this parasite are more pronounced and harmful. Liver disfunction from the presence of this parasite in the Bovidae is well known. Cattle, sheep

TABLE 1.—COMPARATIVE INCIDENCE OF PARASITES IN WINTER-KILL AND COLLECTED DEER

Cause of Death and Age	Species of Parasite and Incidence											
	DICTYOCAULUS			LEPTOSTRONGYLUS			CEPHENOMYIA			FASCIOLOIDES		
	Number	Positive	Per Cent Positive	Number	Positive	Per Cent Positive	Number	Positive	Per Cent Positive	Number	Positive	Per Cent Positive
Winter-Kill												
Adult	24	8	33.3	24	16	66.7	32	14	43.8	30	22	73.3
Fawn	71	23	32.4	75	66	88.0	88	22	25.0	87	5	5.7
Collected												
Adult	59	11	18.6	75	36	48.0	77	20	26.0	93	35	37.6
Fawn	29	5	17.2	43	33	76.7	44	6	13.6	46	3	6.5
Total												
Adult	83	19	22.9	99	52	5.25	109	34	31.2	123	57	46.3
Fawn	100	28	28.0	118	99	83.9	132	28	21.2	133	8	6.0

and goats, however, appear to represent abnormal hosts (Swales, 1935) whereas members of the Cervidae appear to tolerate its presence successfully and can probably be considered the normal host type.

Although no statistically significant correlation was found between winter-kill and presence of either lungworms or nose bots, a significant relationship was found between the terminal pneumonias so frequently present and *Leptostrongylus* infections. Lung pathology from this worm's presence has been well described by Goble (1941). Lung pathology in response to superinfection has been described by the writer (Cheatum, 1948). The greatest damage from this parasite results from the inflammatory reaction to eggs and newly hatched larvae in the interstitial tissues and in the alveoli. Lungs, sensitized by worm invasion shortly previous to subsequent invasions of third or fourth stage larvae from snails may respond in a strong cellular reaction wherein eosinophilic white blood cells are rapidly mobilized around the invading larvae of superinfections. These result in hard nodules and disfunction of the involved tissue. Where large numbers of eggs and larvae are present, (and hundreds may be produced by a single female) mucous inflammation results which leads to blockage of bronchioles supplying alveoli. The latter may collapse and the affected portion of lung temporarily loses respiratory function.

These effects are obviously damaging but it has been thought that secondary bacterial infections of lungworm lesions may have been of more severe, immediate consequence in producing the gross lung changes suggesting pneumonia. It was hoped that a bacteriological investigation of the normal flora of deer lungs could be made and followed by isolations from the pneumonic tissues. This would have shed light on the possible role of bacterial secondary infections in the terminal pneumonias so commonly seen in winter-kill deer. This phase of study was never undertaken, however, and yet remains for elucidation.

Nose bots, though producing chronic inflammation of the retropharyngeal pouch, appeared to be confined in their harmful effects to this area. They were occasionally observed in the lower bronchi in deer which had been dead for some time. Since no local inflammation was apparent grossly or microscopically, it was assumed that they had migrated into the lungs after death of the animal. Their more frequent occurrence in winter-kill deer (Table 1) suggests that they too add weight among the multiplicity of factors responsible for

winter mortality of deer in the Adirondacks.

Lack of Shelter and Chilling in Lowering Resistance. As stated earlier, deer were sometimes found to have succumbed before extreme emaciation had developed during the course of winter malnutrition. Foods of fair quality and quantity were found in some stomachs. Although general inanition was involved, their deaths could not be totally accounted for by simple starvation. Again, apparent pneumonias figured in mortality, and it was suspected that excessive chilling could sufficiently lower resistance to allow or precipitate the development of fatal pneumonias. Gerstell (1938) has suggested this. The following excerpt from the writer's Quarterly Report, dated April 1, 1943, will illustrate.

"An interesting collection of 27 'winter-kill' deer from Bay Pond Park in the Adirondacks came in for study. The group consisted of 9 adults, including 5 senile does, 3 younger does from 2–7 years of age, one yearling buck, and 18 fawns. Cattle lungworms (*Dictyocaulus viviparus*) were present in 5 of the adults and in 11 fawns. The deer lungworm (*Leptostrongylus*) affected 5 adults and 14 fawns. Liverflukes (*Fascioloides magna*) were present in 5 adults and none of the fawns. Nose bots (*Cephenomyia phobifer*) were found in only one adult.

"The past winter has been unusually severe. There is no reason to believe that an inadequacy of food accounts for the death of these deer at Bay Pond since food is maintained before them throughout the winter at many feeding stations in this park, and the deer were found dead in the immediate vicinity of feeding stations. An abundance of food was present in all of the stomachs, although the body weights were quite low. Pneumonic areas were present in every pair of lungs and some were heavily involved. Several showed lung hemorrhages with bloody froth in the tracheae. Lungworm infections were not consistantly associated with either pneumonias or hemorrhages. The lung hemorrhages occurring in this group were nearly identical to such cases found among deer chased and killed by dogs, and are often to be found as symptomatic of violent physical exertion. Since no dogs were free in the park areas, I am unable to explain this lung condition apart from the consequences of the pneumonias present, although it is unusual in my experience to encounter such extensive hemorrhage in the pneumonias common among 'winter-kill' deer.

"This group of Bay Pond winter mortalities again raises the question of whether in this area lack of available food of itself is, always, the principal underlying cause of 'winter-kill.' Certain field observations, the results of autopsy, and the age classes most severely affected (fawns and senile animals) seem to indicate that chilling and the consequent lowering of body temperature may sometimes play a decisive role in bringing about pneumonia and death. Chilling and chronic pneumonias may occur before food has been depleted to the point of inaccessibility. Emaciation proceeds with loss of appetite and browsing activity. This has been observed among captive fawns affected by pneumonias resulting from exposure. Fawns and senile animals found dead from such pneumonias contracted in precedence of starvation conditions would present essentially the same picture at autopsy as those dying more directly from food inadequacy. As for contraction of fatal pneumonias in spite of an apparently adequate food supply, the Bay Pond mortalities are clear cut examples."

It must be pointed out that lack of shelter is an unusual circumstance for Adirondack deer. They habitually congregate in heavy coniferous stands in valleys and are only found in inadequately sheltered areas where winter feeding may be practiced on large estates. In the main, however, the observations at Bay Pond serve to illustrate that shelter from the chilling blasts of severe weather is important to winter survival of deer, and help to explain the seeming suicidal habit of their returning winter after winter to the

graveyards of starvation in many of the Adirondack valleys, where then confined by deep snow (Severinghaus, 1947) general inanition becomes the principal predisposing factor to mortality.

SUMMARY AND CONCLUSION

Results from a study of lungworm, liver fluke and nose bot infestations of white-tailed deer show a positive correlation between incidence and intensity of infestations by these parasites and the death of deer from 'winter-kill.' A pronounced relationship assumed to be of a causative nature was found between infestation by the deer lungworm (*Leptostrongylus alpenae*) and the pneumonias so frequently found in deer dying during severe winters.

Malnutrition of both qualitative and quantitative character is considered the basic factor predisposing to death. The parasite load accompanied by their characteristic lesions and debilitating effects apparently reduces the chance of deer survival in severe winter. Lack of adequate shelter in some localities with consequent chilling was indicated to be of perhaps as much importance in precipitating death as inadequate food. This was found especially in the case of fawns and old animals.

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Accepted for publication September 30, 1950.

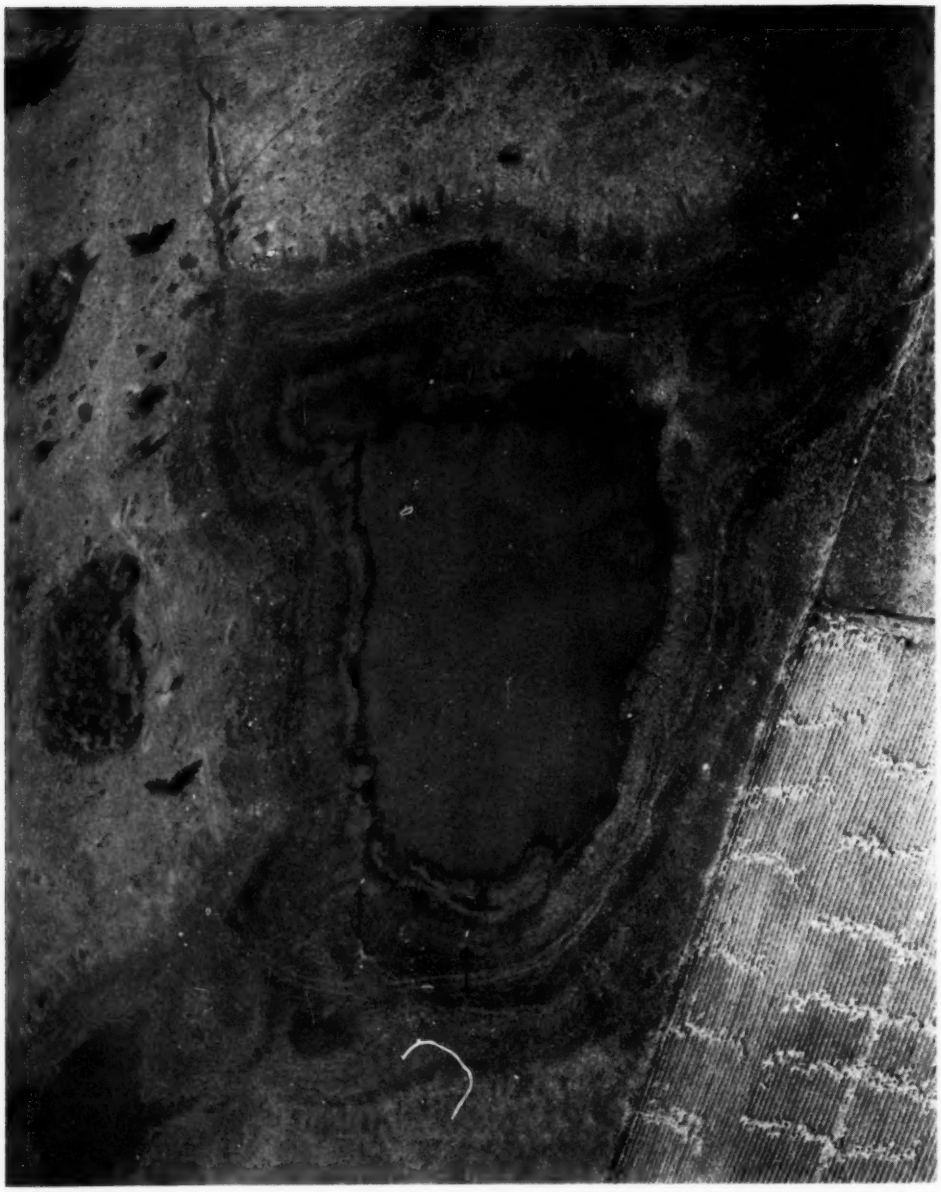

PLATE 9. Northern Minnesota minnow pond showing water levels, vegetation areas, and board markers. Black arrows show location of the markers.

BRIEFER ARTICLES

POND MAPPING BY AERIAL PHOTOGRAPHS

Game and fish workers are often required to map in detail one or more small ponds, but many of these ponds are surrounded with dense vegetation in summer and are covered with such heavy snows in the winter that ground mapping is difficult and very unpleasant. Aerial photographs are a cheap and simple solution to the problem. Those available in most county seats however, are not adequate because of the small scale and the variations in the scale.

For accurate work each pond must be photographed separately from a low altitude. The following method makes use of ground markers a known distance apart and projections from the photographic negatives to produce maps of chosen scale in spite of variations in plane altitude. White boards or strips of white cloth five feet long and eight inches wide can be placed on the shore as markers. On ponds ten acres and smaller these can be 100 feet apart but on larger ones the distance should be 300 or 400 feet. Care must be taken that the markers are not obscured by vegetation or the shadows from vegetation. In wooded areas it is sometimes necessary to anchor the boards in open water. In most cases a set of markers should be placed on each side of the pond so that distortion can be corrected on the final map.

There are many cameras suitable for this work as the job does not require elaborate equipment. The camera, however, should produce a negative that is large enough to be projected to 11 by 14 inches without loss of definition and the lens should be fast enough to allow an exposure of 1/500 of a second under poor light conditions. (Vertical pictures of water require longer exposures than landscapes or similar pictures taken from the ground.) The illustrations for this article were taken with a $3\frac{1}{4}'' \times 4\frac{1}{4}''$ speed graphic on press film. The plane elevation was 1,000 feet, the speed 80 to 90 miles per hour and the shutter speed was 1/500 of a second. This shutter speed was enough to stop the action in most cases.

A vertical picture is easier to take through a hole in the floor of the plane but it is possible to obtain a satisfactory shot from the window. In the latter event when the pond has been lined up in the view finder, a nod of the head will be the pilot's cue to tip the plane on its side. While this operation increases the possibility of distortion in the picture, much of the distortion obtained is due to the difficulty of flying the plane over the center of the pond.

The map negatives should be printed by projection so that each one can be enlarged to the same scale. When the image is projected on the easel, a ruler can be used to measure between the markers and the size of the image can be adjusted to any desired scale. When the negative shows two sets of markers, the easel can be tilted until the distance between both sets measures the same. This corrects the distortion that results from tilting the camera when the picture was taken.

An aerial pond map is cheaper to make than a ground survey and will give more valuable information. If the pond map is made in the fall when the pond is low it will show the low water area, high water mark, inlets, outlets, aquatic vegetation, upland vegetation, buildings, roads and trails.—JOHN DOBIE AND RAYMOND E. JOHNSON, *Minnesota Dept. of Conservation, St. Paul, Minn.*

Accepted for Publication June 30, 1950.

MULTIFLORA ROSE HIPS AS PHEASANT FOOD

During the past two years approximately 1,200 Michigan farms have been furnished with multiflora rose through Michigan's Pittman-Robertson farm-game habitat improvement program. The value of this plant for producing cover and as a living fence has been established in some sections of the country and is on trial in several others.

Little is known about the food value of the abundant fruit of this rose. It is not known or expected to be a major item in the diet of pheasants, but there is a probability of its oc-

casional use. For this reason it is desirable to know whether pheasants can subsist in any emergency on this fruit alone, a situation which could occur during severe winter periods.

An experiment in which multiflora rose hips were fed to pheasants was started February 2, 1949 at the Michigan Department of Conservation's Rose Lake Wildlife Experiment Station. Six ring-necked pheasants from the State's Game Farm at Mason were used, three for controls and three for the test. Control birds were fed on corn and rose hips. The experimental birds were fed exclusively on rose hips.

The experiment was terminated after 27 days since, in a previous study at Rose Lake, pheasants did not survive without food beyond this period of time.

The birds in the control pen showed a preference for the corn, scarcely touching the rose hips. The experimental birds were at first slow in feeding on the rose hips but after four days they ate them readily.

At the conclusion of the study it was evident that the experimental birds not only survived the 27-day rose hip diet, but sustained themselves on it. The scope of the experiment did not include a close check for nutritional deficiencies, but no striking abnormalities were noted by ordinary observation of the experimental group.

The following table shows the weights of the experimental birds in comparison to the weights of the birds in the control pen.

PHEASANT—ROSE-HIP EXPERIMENT WEIGHTS
FEBRUARY 2 TO MARCH 1, 1949

	Pheasant	Entrance Weight Feb. 2, 1949	1st Weighing Feb. 15, 1949	2nd Weighing Feb. 24, 1949	Final Weighing March 1, 1949
Pen #1	118405 m	2 lb. 12.0 oz.	2 lb. 9.5 oz.	2 lb. 7.5 oz.	2 lb. 11.0 oz.
Experimental	118401 f	2 lb. 8.0 oz.	2 lb. 5.0 oz.	2 lb. 2.5 oz.	2 lb. 3.5 oz.
Pen	118402 f	2 lb. 2.0 oz.	2 lb. 1.0 oz.	1 lb. 15.0 oz.	2 lb. 1.0 oz.
Pen #2	118406 m	3 lb. 1.0 oz.	3 lb. 1.0 oz.	3 lb. 1.5 oz.	3 lb. 2.0 oz.
Control	118403 f	2 lb. 1.0 oz.	1 lb. 15.0 oz.	1 lb. 15.0 oz.	1 lb. 14.0 oz.
Pen	118404 f	1 lb. 10.0 oz.	1 lb. 11.0 oz.	1 lb. 11.5 oz.	1 lb. 11.0 oz.

—HERBERT E. JOHNSON, *Game Division, Department of Conservation, Lansing, Michigan.*

Accepted for Publication September 27, 1950.

A MARKER FOR WATERFOWL

The rubber pheasant tag developed by Taber (1949. A new marker for game birds. Journ. Wildl. Mgt., 13: 228–231) was not found to be entirely satisfactory for use on breeding American coots (*Fulica americana*). A smaller, more water-resistant marker was devised which is thought to be usable on water birds generally.

The best material found so far is "Vinylite" plastic rigid sheeting, 0.05 inches thick, obtainable from the Bakelite Corp., New York. This substance is translucent, pliable and weatherproof and available in eight contrasting colors. The marker is a 20 by 60 mm. piece of plastic folded double to form a piece 30 mm. long and 20 mm. wide. The flap that is to be next to the bird is notched about 6 mm. from the fold to facilitate the insertion of a size 1 Oakville stainless steel safety pin. The pin is placed so that it fits snugly into the notches and then copper staples are driven through the plastic above and below the pin to hold it in place (Fig. 1A). Another staple is driven through the plastic near the free ends to make it a one-piece unit.

The marker is pinned to the coot through a large pinch of skin at the base of the skull. The entire open part of the pin should be embedded in order to reduce movement of the marker.

To increase the number of individually recognizable markers, color combinations in pat-

terned squares were devised with a minimum dimension for any one color of 10 mm. and an overall size of 20 mm. square. A pattern of this

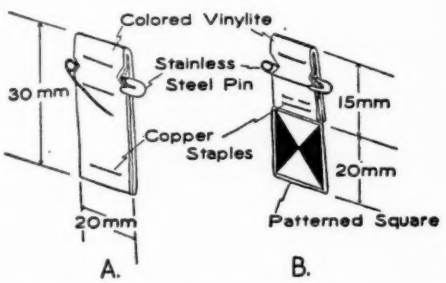

FIG. 1. The two styles of the marker, rear view. A. is the single color style; B. the multi-colored style.

size can be identified at about 100 yards with an 8 x 30 binocular. The colored plastic is cut in the desired shapes to form the patterns shown in Figure 2 and then sandwiched between two pieces of a clear cellulose acetate, using acetone as the binder. After the "sandwich" is dry it is placed in a 20 mm. square, metal mold and compressed by two "C" clamps between two pieces of 1/16-inch iron sheeting, faced with a smooth piece from a tin can. After having been in a 300–350° F oven for about five minutes, the mold is plunged into iced water, disassembled and the "sandwich" removed and trimmed, leaving a 6 to 8 mm. lip to be stapled between the free ends of a 30 mm., folded piece of colored "Vinylite" with a pin inserted as discussed above (Fig. 1B).

Using the 15 mm. side of "Vinylite" as one unit in the color scheme and the 13 field-tested patterns in contrasting bicolor arrangements (Fig. 2), it is possible to mark 3,744 birds individually.

Although it seems doubtful that coot pugnacity would permit a marker of this kind to remain on a bird from one season to the next, it is still a very useful tool when used for short term studies. During the course of the study for which the marker was devised, 56 coots were marked. Among the birds kept under constant observation, the average length of marker retention was about three months. However, these markers were all attached with nickel-plated brass safety pins which cause a somewhat acute tissue reaction. Stainless steel pins were put into use only about one month before the study ended, but observations during that month indicated a very much lessened reaction and hence a considerably lengthened period of retention.

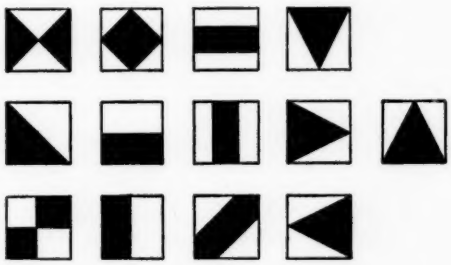

FIG. 2. The 13 field tested marker patterns.

In one trial, using the brass pins, on a pair of mallards (*Anas platyrhynchos*), the markers remained satisfactorily in place from February 3 to at least September 12, 1950.

Acknowledgments.—I am indebted to K. O. Westlye, technical representative of the Bakelite Corporation of New York for the samples of "Vinylite" plastic rigid sheeting used in this study. C. D. Bryan, of the Oakville Company Division, Scovill Manufacturing Company of Oakville, Connecticut, generously supplied the stainless steel safety pins used to attach the markers to the coots.—GORDON W. GULLION, *Museum of Vertebrate Zoology, University of California, Berkeley 4, California.*

Accepted for Publication September 20, 1950.

NOTES ON TRAPPING SHARPTAIL GROUSE IN MANITOBA

The Manitoba Game and Fisheries branch of the Department of Mines and Resources issued an order to certain of its field personnel to trap and band sharptail grouse (*Pediocetes phasianellus*) late in the fall of 1947. The objects of the banding program were (1) to determine whether grouse living in the bush moved to farm land habitat as grouse numbers increased, (2) to see if winter concentrations were made up of local birds, or whether long

movements to wintering areas were involved, and (3) to get longevity information. Bands were to be recovered during the shooting season.

As a provincial game conservation officer my trapping location was on the west side of Lake Manitoba in an area of about 150 square miles around the town of Langruth. The area actually covered by the trapping was much less. This section of Manitoba is in the so-called aspen park-lands. The dominant woody plant is aspen (*Populus tremuloides*). Oak (*Quercus* sp.), bog birch (*Betula pumila*), willow (*Salix* sp.) and saskatoon (*Amelanchier canadensis*) are also found in various combinations and densities. There are no conifers in the Langruth country.

Having had no previous experience with trapping sharptails or with building traps for them, I consulted the Progress Report No. 5 of the Prairie Grouse Cooperative, 1941. The "long-bob" trap was selected as the one to be built and used in the trapping operation. Six newly constructed traps were received from Winnipeg.

Tip-top traps patterned after the Manweiler tip-top (Prairie Grouse Coop. Report No. 5, 1941), but which I built by combining two apple boxes, were used with some success at Langruth and at Delta.

Prebaiting the trapping areas with barley and wheat was begun in January, 1948, but little if any of the grain was eaten. The sharptails remained in the bush, apparently subsisting on the buds of aspen (*P. tremuloides*) and bog birch (*Betula pumila*). Early in March some birds began frequenting set out oat sheaves. The oats were later augmented with barley and cracked wheat. The traps were put into operation on March 10, and began to produce immediately. Unfortunately many of the birds escaped through the bobs either by bending the tines or by slipping through the bobs as they bounced when jarred by other birds. Later I discovered this to be a trapping difficulty experienced elsewhere on other species where bob-traps were used.

Cursory observations and sign at the traps indicated that they were able to hold only about 70 per cent of the birds that entered. In order to minimize this loss we added another row of bobs parallel to the original set. The inner row was slightly offset. Thus, a bird entering the trap had to pass through two rows of bobs. The new arrangement appeared bulky, but losses dropped to less than 10 per cent. Not including labor, the cost to add the extra row of bobs was about one dollar per trap. To my knowledge this is the first use of a double bob on a gamebird trap.

Sexing by means of the pattern on the central tail feathers was used. The first year sexing by this method was subject to some error. The subsequent year's data I believe to be accurate.

It is too early to draw even tentative conclusions from these banding efforts.

The summary of trapping operations by Game Guardian Herb Krantz and myself is as follows:

1948	Langruth	29 females	42 males
1949	Langruth	30	58
1949	Delta	9	6 (3 not sexed)
Total		68 females	106 males

—WILLIAM L. NEWMAN, *Game and Fisheries Branch, Dept. Mines & Resources, Winnipeg, Manitoba.* Accepted for publication September 20, 1950.

OBSERVATIONS ON PREDATOR-PREY RELATIONS BETWEEN WILD DUCKS, TRUMPETER SWANS AND GOLDEN EAGLES

The writer had the opportunity to observe a pair of golden eagles preying on mallard and golden-eye ducks and the cygnets of the trumpeter swans at the Red Rock Lakes National Wildlife Refuge, Montana, during the winters of 1944 to 1947. Both American and Barrow's golden-eyes were represented during this period. The Barrow's golden-eye comprised about 60 percent of a flock of 250 to 300 golden-eyes which wintered regularly at the Refuge. The mallard population totaled 600 to 1000 birds during the period. The trumpeter swan winter population varied from 100 to 170 birds. These species of waterfowl wintered at Elk Springs Creek and Culver Pond, which were fed by warm springs and remained open

throughout the winter. Open water was present at all times, even during temperatures as low as 33 degrees below zero.

Available food for the eagles was chiefly grouse, ducks and an occasional cygnet of the trumpeter swan. The jack rabbit population was very low, possibly one per square mile, and as a result contributed very little to the eagle's diet. These particular eagles were adept bird killers, which may have accounted for their remaining in the snowbound Red Rock Lakes country instead of moving into Idaho, or other regions southward where rabbits were common. The ever-present snow cover and the diurnal feeding habits of the grouse made them particularly vulnerable to the eagles.

The eagles were not regarded as potential enemies by the ducks and swans until they began making an occasional kill of the above species. On one occasion in late November of 1944 the writer observed one of the eagles make three stoops over a flock of swans on a snow covered meadow. The swans stood motionless and apparently had no fear. This eagle was apparently sporting over the swans as no kills had been made up to this time. The eagles made infrequent kills of the smoky grey cygnets, but no adult or white swans were molested. A cygnet was killed at Culver Pond on December 26, 1944, and another was struck in the air and killed on January 1, 1945. Due to these kills the swans were apparently much afraid to visit the feed grounds during January and early February. A total of three cygnets was killed during this winter.

Eagles began killing ducks with considerable regularity during November and December 1946. Duck kills were not all observed since the feathers were soon obscured by frequent snowfalls and high winds. Kills of golden-eyes averaged two to three birds a week. By late December kills appeared more difficult for the eagles which apparently harassed the ducks so often that a defense strategy was developed in the golden-eyes and mallards. Once on the water, the ducks would not leave, and an eagle was powerless to pick one off its surface. The eagles soon counteracted these tactics by concealing themselves in the dense Douglas fir timber on the butte overlooking the pond. They appeared to have discovered that personnel in feeding the swans would flush the ducks from the water if a kill had not been made beforehand. We noted that at least once a week the golden-eyes would be very reluctant to leave the water as we approached to distribute grain. Upon each occasion as the ducks began to fly excitedly 300 yards to another area of open water an eagle would shoot out from the fir timber, where it was hiding, and pick a duck out of the air with great speed and comparative ease. The raptore would then fly off 300 to 400 yards, alight on the snow, and consume the duck. Often its mate would come immediately to share in the feast.

Magpies not suspected of even being present would come from the willow thicket nearby and surround the eagle to grab scraps of flesh. The eagle would become annoyed and strike out at one and, at the same time, two or three cooperating magpies would dash in and grab scraps. The magpies would flirt just out of reach of the raptore, always dodging and scarcely avoiding the eagle. The writer has counted as many as 12 magpies around an eagle as it ate a duck.

The golden-eyes, when flying to the second area of open water, would hurry along in flight and, when near the pond, would literally fall out of the air into the water, so great was their fear of the eagles. The ducks did not fear the eagles except when in flight. The rapid flight of the golden-eyes made them in perfect timing with the eagle's swift stoop. The observer has never seen an eagle miss a golden-eye flying alone. The eagle often overshot mallards due to a difference in flight speeds and the maneuverability of this bird in flight. Had the eagles been catching mallards exclusively no doubt they would have adjusted the speed of the stoop. Since the golden-eyes were their easiest shots, the eagles specialized on the swift dives, and when a mallard was singled out, possibly through error, they would muff their anticipated catch by shooting just a little in front of it. The mallard, of course, seeing the stooping eagle could also slow up sufficiently to assist in avoiding the strike. I also noted that when an eagle made a pass at a group of two or more ducks in flight its chances of a miss were greater than when diving on a single duck. The eagle seems unable to concentrate on any one as it stoops, and as a

result is less successful in making a catch. This was true, at least, for the eagles under observation. Since this pair of raptores was specializing on birds for food they were probably more efficient in making a catch than those depending upon small mammals for a greater part of their diet.

The harassment and duck kills during November 1946 stimulated considerable unrest among the swans and ducks. Fear of the eagles by the swans may have reverted back to experiences of 1944 and 1945, since the former did not kill any cygnets during the winter of 1946–1947. Feed consumed by the swans fell off considerably and their numbers were erratic during December 1946. A well placed rifle shot broke up the pair of eagles in early January of 1947 and the survivor left the region. This seemed necessary since they were creating considerable excitement and fear among the trumpeter swans. The swans and ducks returned to normalcy when the eagles were eliminated.—WARD M. SHARP, *Pennsylvania Cooperative Wildlife Research Unit, The Pennsylvania State College, State College, Pennsylvania.* Accepted for publication August 16, 1950.

REVIEWS

Canada Geese of the Mississippi Flyway with special reference to an Illinois flock. By Harold C. Hanson and Robert H. Smith. Bulletin of the Illinois Natural History Survey, Vol. 25, Art. 3. March 1950. 210 pp., frontis. + 82 figs. bibliog. Illinois Department of Registration and Education, Urbana.

The establishment and development of the Horseshoe Lake Game Refuge in Illinois resulted in the attraction to a small area of an estimated fifty per cent of the Canada geese wintering in the Mississippi flyway. Severe decimation of these flocks by heavy shooting in the public hunting grounds surrounding the refuge brought about more restrictive regulations on hunting geese in that flyway. It also stimulated the Illinois Natural History Survey and the U. S. Fish and Wildlife Service to conduct this cooperative investigation of the Canada goose situation throughout the flyway.

The authors obtained and analysed a great quantity of data from three principal sources—field investigations in the breeding range and wintering grounds, banding data from the Miner station at Kingsville, Ontario and from the Horseshoe Lake station, and kill records from the principal hunting areas, particularly from the Horseshoe Lake region.

The paper is of interest in the field of taxonomy as well as in management research. On the basis of 861 Miner and 228 Horseshoe Lake band recoveries of *Branta canadensis interior* from its breeding range, four well-defined subpopulations have been described. These subgroups migrate and winter in four slightly overlapping but quite distinct flyways. They have been termed South Atlantic, Southeast, Mississippi Valley and Eastern Prairie populations. Wildlifers might conjecture what the taxonomic result may be when some "splitter" recognizes them as examples of incipient subspeciation!

With regard to banding methods it is mentioned that Jack Miner did not serially number his bands. In order to avoid misunderstanding, it should be explained that, in recognition of his pioneer banding work before the official system was established, the Canadian authorities have allowed Jack Miner and the present Miner Migratory Bird Foundation to continue to use their own bands. All other Canadian banders of migratory birds use the standard bands provided by the U. S. Fish and Wildlife Service.

Waterfowl researchers will be interested in the excellent description, with aerial and ground photographs, of the muskeg country in the Canada goose breeding range around Hudson and James Bays. Reasons for the paucity of information concerning waterfowl production in that country are very evident.

A 20-page section on productivity and population survival contains much thought-provoking data. For example, sex ratios and adult-juvenile age ratios were obtained for almost 7000 geese at Horseshoe Lake; and figures on the relative numbers of juveniles, yearlings, and adult geese are provided for

2359 birds. Severe hunting pressure is blamed for a relatively low survival of the Mississippi valley geese.

The comparative vulnerability of juvenile and adult Canada geese is not easy to measure, as it is in blue and snow geese. The authors employ a vulnerability quotient at Horseshoe Lake derived from seasonal banding data, as the ratio between juvenile band recoveries and total juveniles banded, divided by the ratio between adult band recoveries and total adults banded. In 1943, juveniles were 8.34 times as vulnerable to shooting at Horseshoe Lake as were adults.

In summing up a most interesting discussion of survival data, the conclusion is made that "the average juvenile did not live long enough to produce a brood of young"—a rather obvious fact in wildlife populations.

The hunting of Canada geese in the Mississippi flyway is described in relation to protection and management. The spring kill by James Bay Indians, from 5 to 10 per cent of the available population, is discussed with no mention of its relationship to the Migratory Bird Treaty. Actually this spring kill is contrary to Canadian regulations, but is overlooked at present as necessary to the welfare of the natives.

The authors conclude that the major decimating influence on the Mississippi flyway Canada geese is the severe hunting pressure around the Horseshoe Lake Game Refuge. Recent protective measures have reduced this threat.

This is an extremely comprehensive study of a well-defined goose population. It contains a helpful table of contents, but lacks an index. —OLIVER H. HEWITT.

Potential Conservation Areas Along the Illinois River as Part of Flood Protection. Illinois Department of Conservation, May 1950, 80 pages, numerous plates, maps, and charts.

This publication should be of exceptional interest to all those who have been concerned with the effect of water control projects on fish and wildlife. Prepared as a result of the interest of the Illinois Department of Conservation in developing a plan for flood control for the Illinois River Basin which would result in benefits rather than losses to fish and wildlife, it represents a distinct forward step in finding a solution to the flood problem in this basin. It is the type of constructive criticism which is recommended to others who are concerned with the lack of consideration which fish and wildlife interests have received from the various project planning agencies.

The report points out that floods have always occurred along the Illinois River. Commencing in the latter part of the nineteenth century, a series of drainage and levee districts were organized and developed along the flood plain of the river. These districts were organized according to State laws under encouragement from the State authorities, and with this encouragement much of the entire valley was leveed and drained. By 1914, the width of the flood plain in the lower one-third of the river had been reduced by 80 per cent.

With continued encroachment on the flood plain, floods of equal volume produced stages of greater height and it became necessary to raise the levees. As levees were raised, higher flood stages were produced and a vicious circle ensued. Finally, local interests were forced to ask for government assistance to provide flood protection. A series of State and Federal investigations culminated in the 1945 report of the U. S. Corps of Engineers which recommended a plan of development providing for 14 headwater reservoirs, one lateral storage reservoir, and approximately 391 miles of channel rectification on tributary streams.

The U. S. Fish and Wildlife Service reviewed this plan and in a report dated August 1946 recommended, with the endorsement of the State Conservation Department, that the reservoir plan be modified to provide for only 12 main-stem reservoirs, six lateral storage reservoirs, and the deletion of all of the channel rectification work.

Believing that flood control could be achieved with substantial coincidental benefits to fish and wildlife through the development of lateral storage reservoirs, the State Conservation Department instigated this present study to explore this possibility both from the point of view of engineering and of economics.

The most important conclusions and findings may be summarized as follows:

1. Certain of the drainage and levee districts along the Illinois River may store large quantities of flood water at unit costs

for storage below those of some of the tributary reservoirs proposed by the Corps of Engineers.

2. Fish and wildlife values will be lessened by most of the upstream reservoirs if developed and operated as proposed by the Corps of Engineers in their 1945 report. On the other hand, the use of certain drainage and levee districts as flood storage areas, with coincident use for fish and wildlife, will result in increased yields of these resources.

3. According to the Corps of Engineers' records, the drainage district levees are increasingly responsible for raising flood heights at Beardstown by ten feet and at other Illinois River points below Peoria to a substantial degree. The cutting of the same levees or the use of the old flood plain for controlled storage will cause a substantial lessening of high water crests.

4. In view of the need for flood control and for public hunting and fishing grounds, a joint development plan for the Illinois River should be worked out incorporating both tributary and lateral reservoirs with the lateral reservoirs to be operated for both flood control and fish and wildlife management. Economic justifications for lateral reservoirs, based on monetary benefits for both flood control and fish and wildlife, have been calculated and are presented for 13 levee districts. Of the 13 districts, eight with a total acreage of 51,861 acres have the highest economic justification and are recommended for initial consideration.

The report has presented an interesting and convincing argument in favor of developing the Illinois River Basin along multiple use lines. It is to be hoped that the Corps of Engineers will give it thoughtful consideration. —T. A. SCHRADER

A Survey of the Sierra Nevada Bighorn. By Fred L. Jones. Sierra Club Bulletin, June 1950, Volume 35, No. 6, pp. 29–76.

This survey of the Sierra Nevada bighorn is based on a study of the literature, and field work conducted from early July to early December, 1948. Its purpose was to obtain a broad understanding of the ecological factors affecting the bighorn, in order to plan more effectively for its conservation.

Emphasis was placed on present distribution and numbers, and maps show the early and present distribution of the Sierra Nevada bighorn as well as those of the two other bighorn subspecies in California. There is considerable information on food habits, obtained from transect studies, pellets, and direct observations, and on life history pertaining to physical characteristics, behavior, band composition, sex and age ratios, lambs, water, minerals, and the mating season.

In a consideration of the decimating factors, no indication was found that predation by golden eagles, mountain lions, coyotes, wolverines, bobcats, and ravens has been severe under normal circumstances, a conclusion that has been reached in most bighorn studies in other states. Excessive hunting by white man is considered the chief cause of local extinctions. There are early records of scabies but at the present time the populations appear to be in a healthy condition.

Range deterioration caused by past overgrazing, and current livestock and deer competition are considered vital factors in the welfare of the bighorn, even though the livestock numbers on the ranges have in recent years been drastically reduced: "Presumably, complete protection of the whole winter bighorn range from livestock and adequate management of the deer herds would permit a gradual recovery of the sheep population." It is stated that "hard winters that force the sheep down on lower ranges which have been overgrazed by livestock and deer may cause perio ciddie-offs of considerable magnitude." Winter range has also been found to be the critical factor in other areas where studies of bighorn have been conducted.

The total population in 1948 is estimated at 390. The number of yearlings and lambs noted suggests that the sheep were doing well at the time of the survey. The tentative opinion of the author is that the sheep have passed their low point and that with proper protection and management, a safe and permanent population can be established.

It is urged by the author that the bighorn range be maintained as a wilderness, free from roads, ski lifts, summer lodges, and

improved pack trails: "Mountain wilderness is an ever shrinking commodity that should be guarded in its own right. Mountain wilderness with bighorns is even scarcer, and deserves special priority for complete protection." This excellent ecological study is directly applicable to the conservation of the bighorn and his environment.—ADOLPH MURIE.

Evolution at the population level with special reference to game animals and practical game management, by Paavo Voipio. Game Research Institute, Finnish Foundation for Game Preservation, Helsinki. Papers on Game Research No. 5, 176 pp., 14 tables, 15 graphs, 19 maps, and 1 fig. 1950.

The problems, achievements, and shortcomings of wildlife management as it is practiced and preached in the United States are briefly but penetratingly surveyed in a recent book review by Chitty (J. Anim. Ecol., 1950, 19: 78–80). The tremendous development of game technology within the last two decades is but one measure of the grand scale on which wildlife administration is being carried out in this country. Its policies involve millions of acres of land, the annual expenditure of millions of dollars, and the recreational interests of millions of people. Yet game management is only a part of the much larger and more complex social problem of conservation, by which is meant not merely the jealous hoarding of a few remnants but rather the wise use of our vast supply of all kinds of natural resources. A better understanding and appreciation of this problem is needed even more than further technological improvement. The American public, in general, seems to lack what Aldo Leopold called an 'ecological conscience.' One consequence of this is a widespread failure among the makers of laws and policies to act in accordance with the advice of the wildlife technicians. If the former are to be convinced, the latter must see to it that this knowledge embraces "the concepts and working hypotheses of current ecological thought," for "while a technology cannot be judged by the extent of its contribution to science, it may be criticized if it fails to make the best use of scientific principles."

The effort to establish the practice of wildlife management upon a firm foundation of scientific principles is nowhere better illustrated than in the various publications originating from the Finnish Foundation for Game Preservation. Its two series, *Suomen Riista* (Game in Finland) and *Riistatieteellisiä Julkaisuja* (Papers on Game Research), initiated within the last five years, have already set an extremely high standard. Their usefulness is greatly enhanced by the fact that articles in *Suomen Riista* are almost always provided with a full English summary, while all of the Papers on Game Research to date have been published entirely in English. The latter are contributions from the Foundation's Game Research Institute and are of special interest to wildlife managers. The most recent of these, Paper No. 5, is the treatise under review.

Whereas the question so often asked of American game management is "How can we make our game populations *bigger*?," the author of this paper sets himself the question "How can we make them *better*?" This in turn involves the problems of whether wild game stock can be improved in quality as well as in yield capacity, and of what we need to know to answer this. The author is clearly well-prepared to investigate this subject, for his presentation demonstrates a first-rate comprehension, not only of the principles of population genetics that have been elucidated by Dobzhansky, Fisher, Haldane, Wright, and others, but also of the facts of inherited variation in wild populations as reported, for example, by Dice and Sumner for mammals, Lack, Mayr, and Miller for birds, and Dubinin and Timofeeff-Ressovsky for *Drosophila*. For illustrative material he has drawn upon a broad knowledge of North American, Asiatic, and European game species, as well as upon his own considerable field experience with wildlife conditions and problems of Fennoscandia in general and of Finland in particular. Much of the Finnish material, such as the analysis of polymorphism in the red squirrel and red fox, and the data for muskrat, moose, and arctic fox, is either presented for the first time or has not previously been widely accessible to American game technicians. The result is a notable contribution to wildlife research. The author does not pretend to supply a definitive answer to the problem of game improvement, but his approach places it on a

solid footing of sound theory and orientation.

The account is divided into five principal sections. Parts I and II are introductory and brief; they state the two fundamental prerequisites for the qualitative improvement of game species. These are (1) the existence of heritable variation in the game populations, and (2) a knowledge of the genetic structure and behavior of these populations. Parts III and IV are somewhat longer and present the information demanded by prerequisites (1) and (2) respectively. Eighty-two pages, or about half of the entire treatise, are devoted to Part V. This consists of a discussion and evaluation of both active and passive measures to promote and protect game quality. Throughout, the logical and careful exposition lends much weight and clarity to the argument.

Game populations, like those of other wildlife, exhibit both continuous and discontinuous genetic variation, often geographically distributed and involving not only morphological characters such as size (brown bear), relative length of body parts (moose), and color (partridge), but also physiological features such as temperature tolerance (muskrat) and pattern of molt (weasel) and ecological characteristics like the choice of habitat (willow grouse) and the tendency to migrate (goshawk). These populations may exist as large, more or less continuous units, or they may be broken up into many small and comparatively isolated entities, and between these two extremes exists a wide range of intermediate conditions. It is well-known that the more complete the isolation of a small population, the greater the likelihood of a change in its genetic constitution due to random gene loss or fixation. The loss of genes reduces hereditary variation and results in a decreased ability to adapt to changing environmental conditions. Population deterioration may also be accompanied by an increasing disproportion of the sexes, which tends further to disturb the situation. The irregular distribution of many habitats favors the formation of small population units, but migratory movement opposes complete isolation. Fluctuation in numbers may result in gene loss during a population minimum or in the fixation of genes, which may alter the gene frequencies of the expanding population. Therefore, a knowledge of the effective population size, i.e. the total number of individuals actually engaged in the perpetuation of genes through breeding, is important in the consideration of game management.

One example which may not be familiar to American students of wildlife seems particularly illuminating. This concerns the Finnish moose. In recent years a form with rounded antlers (the *cervina* type) has been gaining ground in the population at the expense of the form *palmata*, whose fan-shaped antlers are considered more beautiful and are more highly prized by hunters. In the 1920's poaching almost extinguished the moose population of Finland, leaving small units in the southwest which were isolated from the northern and eastern moose districts. These southwestern populations are now largely of the *cervina* type, the viability of which is apparently superior to that of the palmate form. Subsequent protection and rather extensive immigration from East Karelia have renewed the Finnish population and have reunited the previously isolated units. In the ensuing competition between the two forms, the *cervina* type appears to be supplanting the original and (to trophy seekers) more valuable type.

In the utilization of natural mechanisms as improvement measures, it is desirable to distinguish between the *promotion* and the *protection* of game quality. Among suggested promotional measures are (1) the introduction of a more valuable form into a population of inferior quality, (2) the elimination of a poor local race to permit natural recolonization by better stock from adjacent areas, and (3) favoring the most valuable varieties of polymorphic forms by selective removal of the less valuable. The author does not hold out any great hope of success from these measures, except under rather special conditions, for in general the population already occupying an area is best adapted to it. The prospects seem brighter for the protection of quality by (1) controlled levy and regulation of the sex ratio on the basis of effective population size, (2) efforts to prevent the formation of small isolated population units by maintaining suitable environmental conditions and by encouraging free movement of individuals, and (3) hindering the fixation or offsetting the loss of genes in small populations by the addition of satisfactory stock.

There is very little in the treatise that calls

for criticism. The translation has been well done, the printing is very satisfactory, and there are no more than the usual number of typographical errors. It is disappointing not to find any tests of significance applied to the statistical treatment of data, and one has to be content with such phrases as "perceptibly higher," "the difference is probably not one of chance," and "a distinct correlation can be observed." Perhaps most serious is the preoccupation with the genetic implications of introductions, selective eliminations, etc., and a neglect of the ecological effects of these measures upon the natural communities of which the game populations are only a part. Introduction, for example, has so often got completely out of hand and has had such disastrous consequences that it ought to be employed only with extreme caution. The relations of game species to the fauna and flora with which they are associated and upon which their existence may depend seem fully as important as a knowledge of the game populations themselves. This of course is clearly recognized by the author, whose primary purpose has been to apply the principles of population genetics to the management of game, and any disagreement here is merely a matter of emphasis. This treatise provides another example of the complementarity of genetics and ecology in the study of evolution.

Wildlife students in general, and game managers and technicians in particular, will find this an unusually stimulating and valuable addition to the five-foot shelf of wildlife literature.—FRANCIS C. EVANS, Laboratory of Vertebrate Biology, University of Michigan, Ann Arbor.

The Invasion of New Zealand by People, Plants and Animals. The South Island. By Andrew Hill Clark, Rutgers Univ. Press, New Brunswick, 465 pp. illus. 1949.

This book is not a book on animal management, it is not even a biology book. This book written by a geographer deals with the geography and history of New Zealand. It tells about the various introductions and immigrations into the island. The present writer is not an expert on New Zealand (nor in reviewing books for that matter) and for that reason was not snooping around for mistakes, mispellings, inconsistencies or misrepresentations. He would, however, like to point out the possible value of this publication to wildlifers, particularly the ones who believe that we can improve our gunning by introducing exotics.

The first part is devoted to the history of settlement. It is interesting reading, the most interesting part of the book, for that matter, even though only glimpses here and there refer to biological problems, for instance the whales and seals that were hunted to extinction. The second part deals with the introduction of domestic animals, many of which have become wild, and only too shortly with the introductions made purposely to improve the fauna. The last chapter deals with introduced plants. Again unfortunately the emphasis is on domestic plants.

Animals and plants were introduced by "Acclimatization Societies" which sprang up in the middle of the 19th century as a result in part of the wish to hunt, symbolizing according to Clark, freedom from class discrimination in England. By 1864 dozens of varieties of birds, fish, rabbits, hares, deer, moose, wapiti, tahr, chamois, wallaby, opossum etc. had been introduced. Twenty years later weasels, stoats, domestic cats, ferrets were set out by the government in the hope that they would war on rabbits. The predators were more interested in the flightless birds and the weka which became all but extinct. The weka, according to Clark, was one of the few effective indigenous enemies of the rabbit.

The government hoping to create a large game area which would attract tourists continued importations of game animals until World War I. After that War, some protective seasons were removed for deer, chamois, and tahr and bounties on tails were paid. By 1931 all protection was removed throughout the South Island. Organized destruction parties during the last years have destroyed large introduced mammals at a rate which is believed exceeds their natural increase.

One hundred woody plants have been established besides endless species of weeds. Weeping willows line river valleys, country drives are lined by lombardy poplars. During every decade of the 19th century different species of trees were in fashion and their seeds introduced. Gorse, though very valuable for hedgerows and cover along the coast, spread

and is displacing native vegetation. Scale insects have been introduced to fight the gorse. Orchards have to be sprayed to protect them from invading scale insects.

Unfortunately (for our purposes) the author is a geographer, more concerned with historical and economical aspects than with ecology. We heard about the introduction of many song birds but not about their effect on the native flora. There are some notes about changes of behavior and breeding potential of the red deer after having been transplanted but this interesting subject is not taken up. No answer is given to the question created by the New Zealand sportsmen's inability to control the game. Did the over-abundance discourage the sport? However the bibliography probably makes it possible for the reader to follow up the many interesting questions that will be suggested to him by reading the book.—HERBERT W. LEVI

Conservation Education in American Schools. 29th Yearbook, American Association of School Administrators, National Education Association, Washington, D. C. 527 pp. $4.00.

Increasing recognition of the necessity for teaching conservation in the public schools is emphasized by this volume which places American school administrators definitely on record. The volume was organized by a "Commission on Conservation Education in American Schools," which included, in addition to several of the school administrators, Dr. Hugh H. Bennett, Secretary Oscar L. Chapman of the Department of the Interior, and Dr. Paul B. Sears, of Yale University. The volume was clearly prepared to aid the teacher in his or her efforts to bring conservation into the public school curriculum, and for this purpose, it is of undoubted value. There is a tremendous amount of information of just the type needed by school teachers in both elementary and secondary schools.

The main body of the attractive volume consists of ten chapters in a general vein, including considerable subject matter, but concentrating on methods of teaching, and giving examples of good conservation teaching programs now in progress. The appendix contains a 40-page bibliography of references on conservation education which appear to be very carefully selected, and 25 pages of audio-visual materials available on conservation and resource use. These sections are certain to be particularly helpful to the teacher.

The chief interest of the volume to Wildlife Society members will be to have a source book to which one can refer teachers when they ask for assistance with their conservation units.—G. A. SWANSON

NEWS AND NOTES

In cooperation with the Patuxent Research Refuge, Dr. Arnall Patz is conducting an investigation of *retrolental fibroplasia*, a condition which causes child blindness in approximately 20 per cent of low birth weight infants. The opossum has been suggested as a logical experimental animal for parallel studies because of the stage of immaturity at which opossums are born. Dr. Patz needs a considerable number of female opossums which are either pregnant or are carrying young in their pouch, and is in a position to pay $6.00 each, plus the transportation and other charges incident to shipping. Animals or communications regarding them should be addressed to Dr. Arnall Patz, c/o Director, Patuxent Research Refuge, Fish and Wildlife Service, Laurel, Maryland.

The Nebraska Game, Forestation and Parks Commission is subsidizing the publication of the first paper in this issue to the extent of paying for the illustrations, tables and text pages beyond 20. This is in accord with a decision of the council that papers beyond 20 pages in length will be accepted only on those terms.